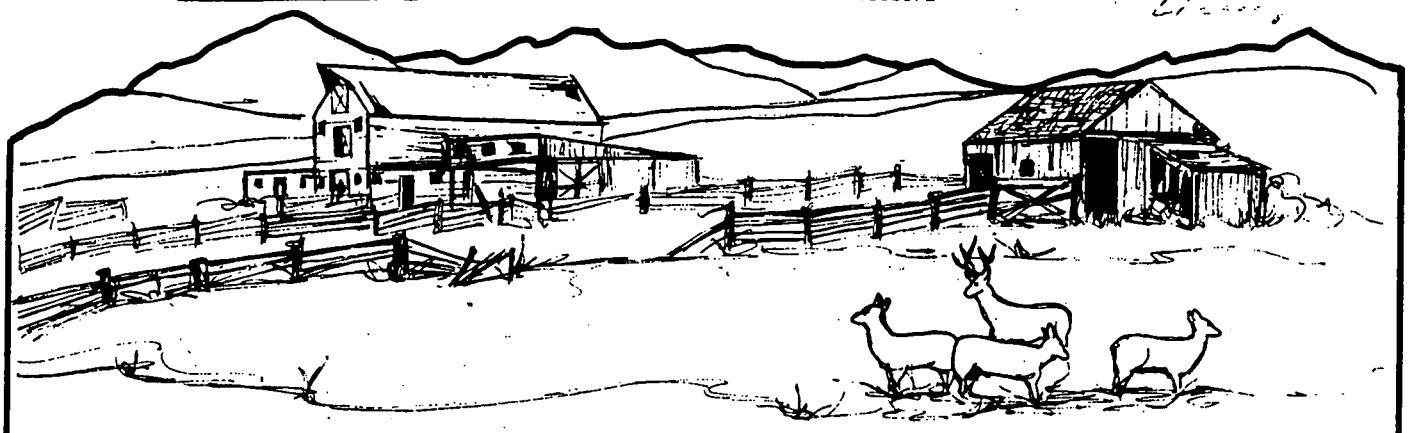

ANNUAL ENVIRONMENTAL MONITORING REPORT

JANUARY-DECEMBER 1980

Rockwell International
Energy Systems Group
Rocky Flats Plant

UNITED STATES DEPARTMENT OF ENERGY
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U. S. DEPARTMENT OF ENERGY, ROCKY FLATS PLANT
January Through December 1980

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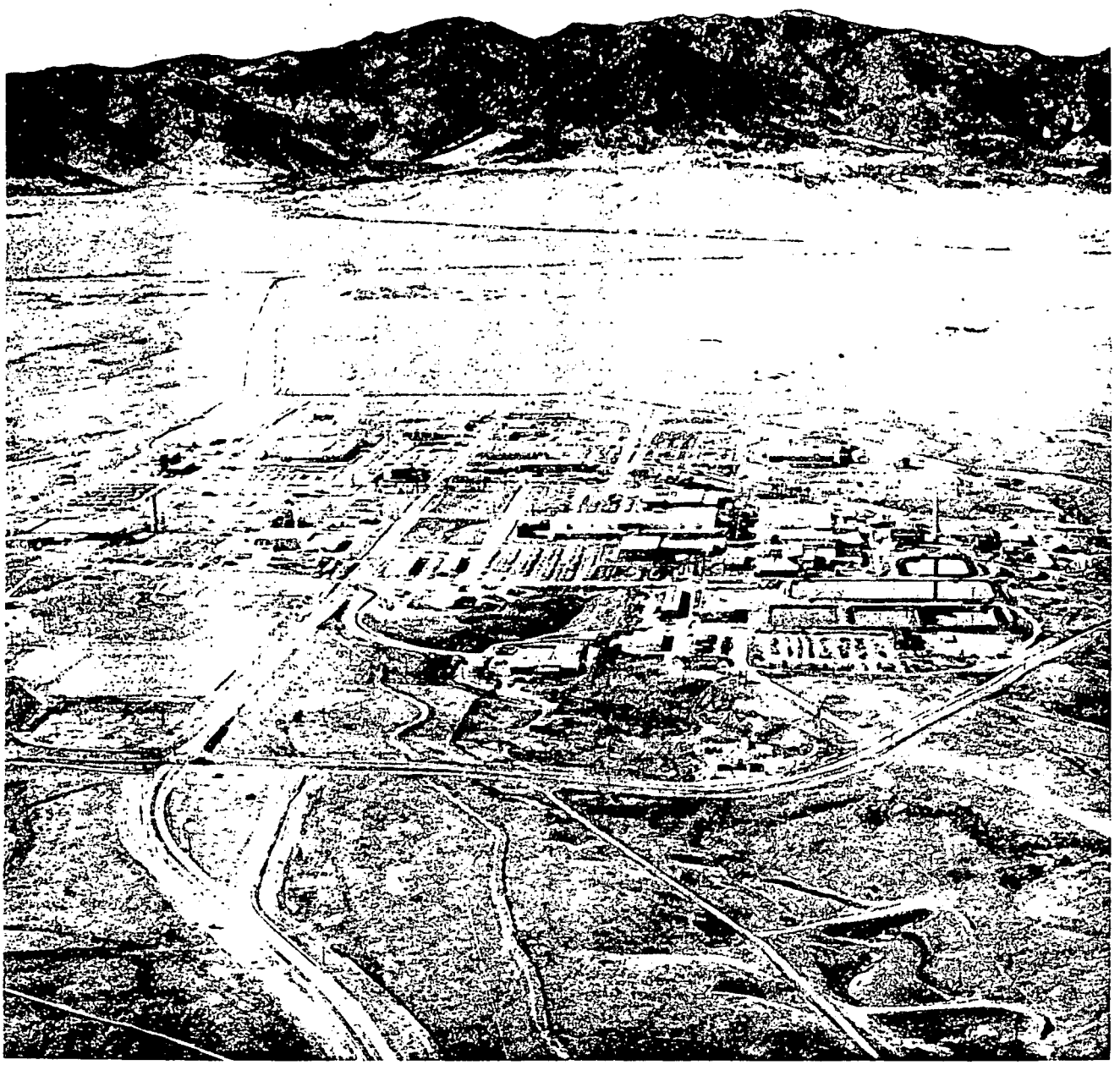

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ABSTRACT

This report documents the 1980 environmental surveillance program at the Rocky Flats Plant, as conducted by the Environmental Analysis Section of the Environmental Sciences Branch. Sample analyses are performed by the Health, Safety and Environmental Laboratories of the Health, Safety and Environment Department and by the General Laboratory of the Quality Engineering and Control Department. This report also includes an evaluation of Plant compliance with all appropriate environmental guides, limits, and standards. Potential public radiation dose commitments were derived from average radionuclide concentrations measured at the Plant property boundaries and in surrounding communities.

ANNUAL ENVIRONMENTAL MONITORING REPORT
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INTRODUCTION

The Rocky Flats Plant is a government-owned and contractor-operated facility. It is part of a nationwide nuclear weapons research, development, and production complex administered by the Albuquerque Operations Office of the U.S. Department of Energy (DOE). The prime operating contractor for the Rocky Flats Plant is the Energy Systems Group of Rockwell International.

The Rocky Flats Plant is located in northern Jefferson County, Colorado, almost equidistant from the cities of Boulder, Golden, and Arvada. (See Figure 1.) The facility, located at 105°11'30" west longitude and 39°53'30" north latitude, is approximately 26 kilometers (16 miles) northwest of downtown Denver. The site consists of 2,650 hectares (6,500 acres) of federally owned land. As shown in Figure 2, major Plant structures are located within a security-fenced area of 155 hectares (385 acres).

The Plant is a key DOE facility that produces components for nuclear weapons; therefore, its product is directly related to national defense. The Plant is involved in fabricating components from plutonium, uranium, beryllium, and stainless steel. Production activities include metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Research and engineering programs supporting these activities involve chemistry, physics, materials technology, ecology, nuclear safety, and mechanical engineering.

As part of DOE's energy research programs, a Small Wind Energy Conversion Systems test facility has been constructed in the northwest corner of the Rocky Flats Plant site to test small wind-energy machines. This test facility is a national research center for the development and testing of wind energy devices.

The more than 100 structures that now exist on the Plant site contain about 189,000 square meters (2.03 million square feet) of floor space. Of this space, major manufacturing, chemical processing, plutonium recovery, and waste treatment facilities occupy about 156,000 square meters (1.68 million square feet). Major laboratory and research buildings occupy about 13,850 square meters (149,000 square feet). The remaining floor space is divided among administrative, utility, security, warehousing, storage, and construction contractor facilities.

All of the Plant's heating requirements are supplied by in-plant steam boilers that normally use natural gas but are also capable of using fuel oil. During Calendar Year 1980, approximately 21.0 million cubic meters (742 million cubic feet) of natural gas and approximately 61.7 thousand liters (16 thousand gallons) of fuel oil were used. Raw water is purchased from the Denver Water Board and is drawn from Ralston Reservoir and the South Boulder Diversion Canal. The Rocky Flats Plant used approximately 391 million liters (103 million gallons) of water during 1980.

The piedmont of the Front Range of the Rocky Mountains rises 8 kilometers (5 miles) west of the site and crests at the Continental Divide, which is 32 kilometers (20 miles) from the Plant. The natural environment of the Plant site and vicinity is influenced primarily by the Front Range of the Rocky Mountains and the site elevation, which is 1,829 meters (6,000 feet) above sea level. The surficial geology of Rocky Flats consists of a thin layer of gravelly topsoil underlain by a 6- to 15-meter (20- to 49-foot) thick layer of coarser, clayey gravel. This, in turn, is underlain by an impermeable bedrock structure upon which the Plant's building foundations are supported. Area hydrology is influenced by the topsoil, which consists of gravelly and highly permeable alluvium. Water retention in the soil is poor, and vegetation

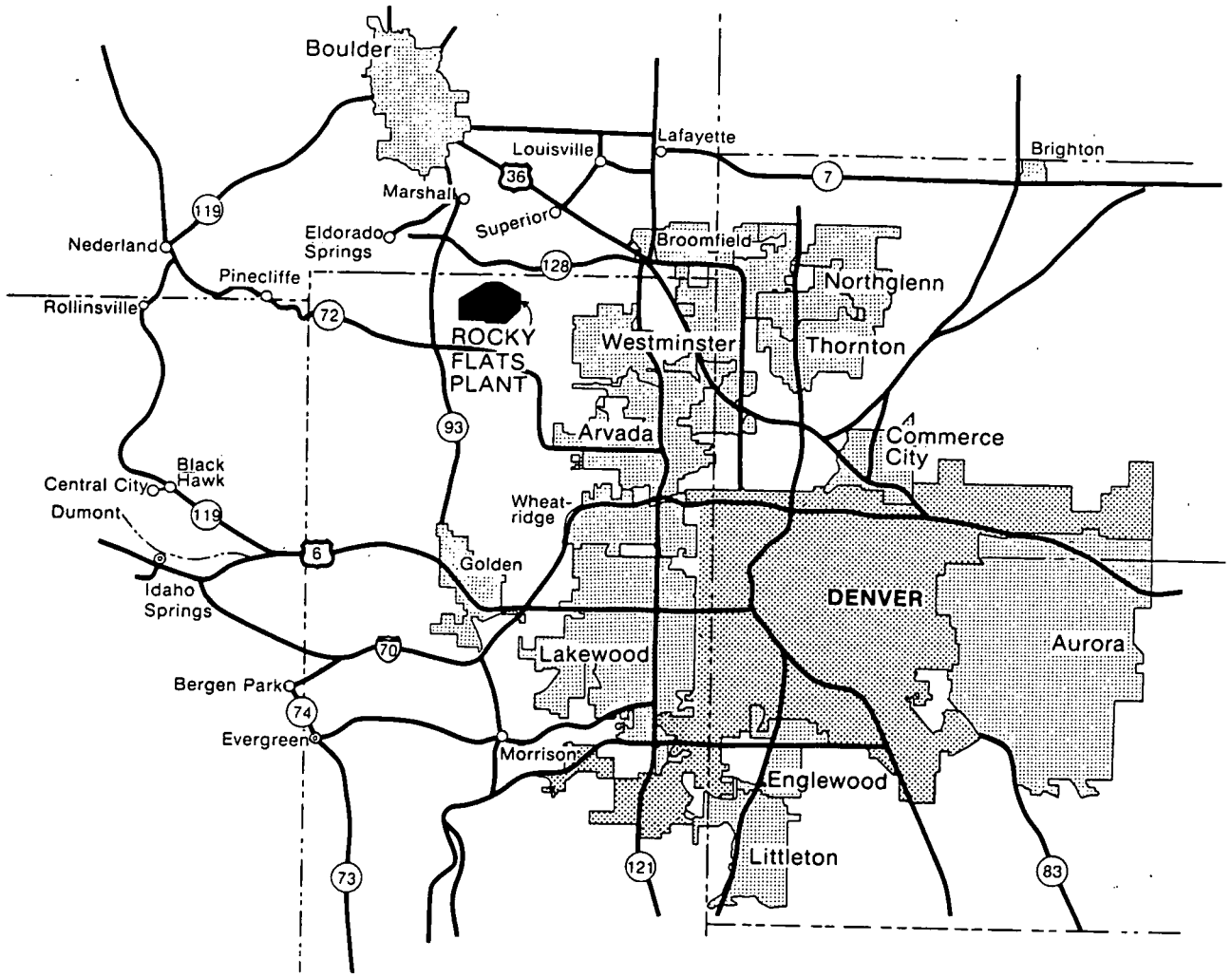

FIGURE 1. Area Map of Rocky Flats Plant and Surrounding Communities

in the area is sparse. Cactus, such as prickly pear and spanish bayonet, and grasses representative of a mixed short- and mid-grass plain, constitute the main ground cover, and cottonwood trees grow adjacent to watercourses. Introduced Eurasian weeds also make up part of the flora. The geographic features of the Plant, in combination with rocky soil, low rainfall, high winds, and solar radiation, produce a harsh, semiarid climate.

The climate at Rocky Flats is characterized by dry, cool winters and warm, somewhat moist summers. There is considerable clear-sky sunshine, and the average precipitation and relative humidity are low. The elevation of the Plant and the major topographical features of the area significantly influence the climate and meteorological dispersion characteristics of the site.

Winds at Rocky Flats, although variable, are predominantly westerly, with stronger winds occurring during the winter. During 1980, approximately 63 percent of the winds had a westerly component.

Annual average precipitation at the Rocky Flats Plant is slightly over 38.1 centimeters (15 inches).

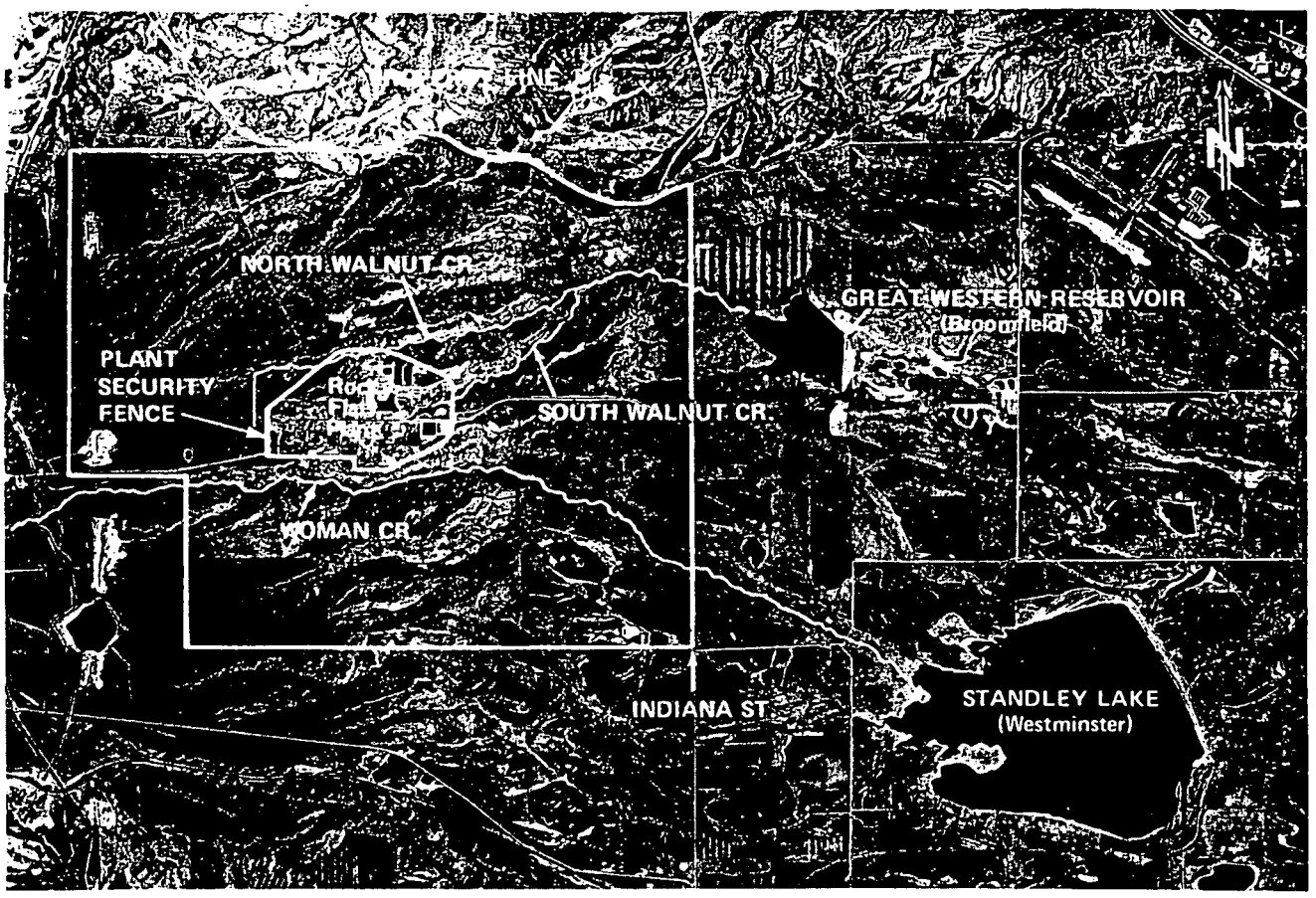

FIGURE 2. Aerial Photograph of the Rocky Flats Plant and Immediate Vicinity 15299

The maximum yearly precipitation recorded over a 24-year period was 63.17 centimeters (24.87 inches) in 1969. Normally, more than 80 percent of the precipitation falls as rain between April and September. Most of the remaining precipitation is in the form of snow.

As shown in Figure 3, surface water runoff from the Plant is from west to east. Runoff is carried from the Plant by three major drainage basins that are tributary to Walnut Creek on the north and to Woman Creek on the south. The south fork of Walnut Creek is the main effluent watercourse from the Plant. The confluence of the north and south forks of Walnut Creek is 1.1 kilometers (0.7 mile) west of the Plant's eastern perimeter. Great Western Reservoir, a water supply for a portion of the city of Broomfield, is 1.6 kilometers (1 mile) east of this confluence. Woman Creek flows east from Rocky Flats into Standley Lake, a water supply for the city of Westminster and for portions of the cities of Northglenn and Thornton. Ponds on the north fork of Walnut Creek receive surface runoff and are designated A-1 through A-4. Ponds on the south fork are designated B-1 through B-5. These ponds receive runoff and/or sanitary wastewater. Pond C-1 is located on the Woman Creek watercourse. Pond C-2, located near the Woman Creek watercourse, receives runoff water from an interceptor ditch.

Exhaust gases from production and research facilities are continuously discharged to the atmosphere by 37 ventilation exhaust systems. Prior to atmospheric discharge, the exhaust gases are passed through particulate filtration systems to

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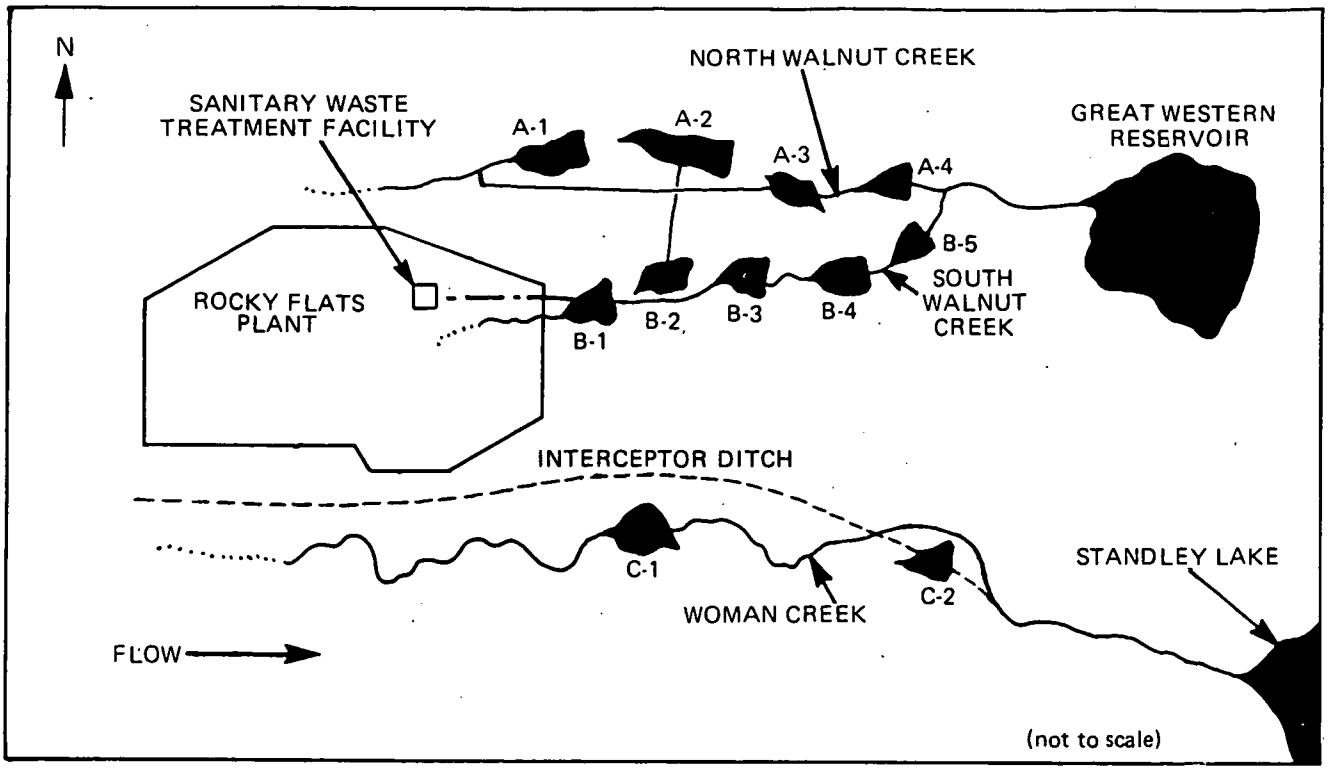

FIGURE 3. Holding Ponds and Liquid Effluent Watercourses

remove potentially radioactive particulates. The filtration systems employ the best air cleaning technology available. Each stage of filtration is tested to assure a minimum efficiency of 99.95 percent for the removal of particulates. Airborne radioactivity released to the environment from process operations is kept to a minimum and is well within Plant health and safety guidelines.

Liquids subject to radioactive contamination are carefully controlled, collected, and processed to remove contaminants. These contaminants are then concentrated, solidified if necessary, and packaged for shipment to a DOE-approved storage facility. The Waste Operations Branch at Rocky Flats handles all liquid process wastes and provides treatment to prepare the wastes for disposition. Process waste liquids are not discharged offsite.

Sanitary waste is processed by the sanitary waste treatment plant. Conditioning chemicals are added, and some organic wastes are biologically degraded to carbon dioxide. The treatment plant is of the activated sludge type and has three stages of treatment. It has a design capacity of 1,700,000 liters (450,000 gallons) per day. Present daily flows usually vary between 570,000 and 950,000 liters (150,000 and 250,000 gallons) per day in dry weather. One of two 260,000-liter (70,000-gallon) preaeration holding tanks, located upstream from the sewage plant, serves as a surge basin to smooth out peak flows. A second holding tank provides storage capacity for sanitary wastes from plutonium process areas, should emergency retention be required. Effluents from the sanitary waste treatment plant either are released to holding ponds for subsequent onsite irrigation or are pumped to a relatively new reverse osmosis facility for treatment. During 1980, no effluent from the sanitary waste treatment plant was discharged from the ponds. The residual solids, containing most of the insoluble organic and inorganic materials, are concentrated, dried, packaged, and shipped to a DOE-approved storage facility.

A portion of the chlorinated sanitary effluent water from tertiary treatment is transferred, for further treatment, to the reverse osmosis plant, which became operational in 1980. The product water is stored in holding ponds for use in Plant cooling towers. Reverse osmosis brine is sent to process waste treatment for evaporation and drying, and the salts are packaged and shipped to a DOE-approved storage site.

Operations at the Rocky Flats Plant may involve or produce radioactively contaminated liquids, solids, and gases. Radioactive materials are handled in accordance with stringent procedures and within multiple containments (physical barriers) designed to minimize the release of contaminants to the environment. The radioactive waste systems include local collection, filtration, liquid processing, and temporary storage facilities for those process wastes known or suspected to have been in contact with radioactive materials. The liquid waste processing system concentrates unrecoverable plutonium into a solid waste suitable for shipment, along with other contaminated solid wastes, to a DOE-approved storage facility. Solid wastes are concentrated, when necessary, and packaged for shipment to a DOE-approved storage facility. Specific details of the Plant's waste processing facilities are described in the Rocky Flats Plant Site Final Environmental Impact Statement.[1]

Nonradioactive solid wastes are transferred to an onsite sanitary landfill for disposal. This landfill was designed and constructed in 1974 as a disposal site for nonradioactive waste materials. It includes an impervious clay seal layer and diverter ditches for surface water and groundwater diversion. Routine materials are checked daily for radioactivity at the landfill site before final burial. The disposal of nonroutine or special waste materials is administratively controlled.

Groundwater and surface water flow in and around the sanitary landfill is controlled by interceptor trenches and by french drains. The trenches divert all upgradient waters around the landfill. The drains collect groundwater from the perimeter of the landfill and divert it around two holding ponds. These holding ponds collect subsurface drainage from the landfill itself. Water samples from the holding ponds, drains, and three test wells in the vicinity are collected periodically and are analyzed for pollutants and radioactivity before the effluent is released for use as irrigation water.

Personnel in the Environmental Sciences Branch of Rockwell International at Rocky Flats conduct an extensive environmental surveillance program. This program is designed to provide assurance that the many safeguards at the Plant effectively limit the release of radioactive or toxic materials. Environmental Sciences personnel assist various operating groups in adhering to the DOE policy that "...operations shall be conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and economically practicable."[2]

The environs are monitored for ionizing radiation and for pertinent radioactive, chemical, and biological pollutants. Air, water, soil, and vegetation are sampled on the Plant site and throughout the surrounding region. Several Federal, State, and local governmental agencies independently conduct additional environmental surveys on and off the Plant site. The Colorado Department of Health samples air, soil, and water at the Rocky Flats site and in surrounding communities. It also operates an onsite, continuous, particulate air sampler for the Jefferson County Health Department. The DOE Environmental Measurements Laboratory (EML) conducts particulate air sampling at the Rocky Flats Plant and periodically performs special studies, including sediment and soil sampling and analysis. Additional special sampling has been performed by the U.S. Environmental Protection Agency (EPA).

Plutonium concentrations measured at Rocky Flats represent the alpha radioactivity from plutonium isotopes 239 and 240, which constitute over 97 percent of the alpha radioactivity in plutonium handled at the Plant. Reported uranium concentrations are the cumulative alpha activity from uranium-233, -234, and -238. Enriched and depleted uranium are the principal types of uranium handled at Rocky Flats. Uranium-235 is the major isotope by weight (93 percent) in enriched uranium; however, uranium-234 accounts for approximately 97 percent of the alpha activity

of enriched uranium. In depleted uranium, the combined alpha activity from uranium-234 and -238 accounts for approximately 99 percent of the total alpha activity. The Radioactivity Concentration Guides[2] (RCG's) used in this report for uranium in air and water are those for uranium-233 and -234, which are the most restrictive guides.

The information contained in this report is submitted in compliance with Department of Energy Order 5484, and is a compilation of data provided monthly to the DOE Rocky Flats Area Office, the Radiation and Hazardous Waste Control Division of the Colorado Department of Health, Region VIII of the EPA, the health departments of Boulder and Jefferson Counties, and to interested city officials in communities near the Plant.

SITE METEOROLOGY AND CLIMATOLOGY

During 1980, wind and temperature data were collected at two different locations near Plant buildings. The data were summarized from strip charts, onto which the raw data had been recorded.

Table 1 is an annual summary of the percent frequency of wind directions (16 compass points) divided into four velocity categories. The compass point designations indicate the true bearing when facing against the wind. The frequency values in Table 1 are presented graphically in the form of a wind rose in Figure 4. The wind rose vectors also represent the bearing against the wind (i.e., wind along each vector blows toward the center). The predominance of westerly (west to east) winds is typical for Rocky Flats. The absence of winds greater than 16 miles per hour with easterly components is also normal.

Temperature data are summarized in Figures 5 and 6. Figure 5 is a presentation of the 12 monthly maximum and 12 monthly minimum temperatures during 1980. For comparison, the average monthly maxima and minima for the 24-year period 1953–1976 are also presented. Figure 6 shows a

TABLE 1. Wind Direction Frequency, by Four Wind Speed Classes, at the Rocky Flats Plant During 1980[a]

	Calm	1-5 (mph)[b]	6-15 (mph)[b]	16-30 (mph)[b]	> 30 (mph)[b]	Total
–	2.7	–	–	–	–	2.7
N	–	2.8	2.3	–	–	5.1
NNE	–	2.7	1.5	–	–	4.2
NE	–	2.7	1.1	–	–	3.8
ENE	–	2.3	1.3	–	–	3.6
E	–	2.5	3.3	–	–	5.8
ESE	–	2.6	2.9	–	–	5.5
SE	–	1.6	2.5	–	–	4.1
SSE	–	2.0	1.0	–	–	3.0
S	–	2.0	0.7	–	–	2.7
SSW	–	2.3	1.1	0.1	–	3.5
SW	–	3.0	1.6	–	–	4.6
WSW	–	4.1	5.8	0.9	0.1	10.9
W	–	3.6	6.7	2.8	0.2	13.3
WNW	–	4.3	4.8	1.0	–	10.1
NW	–	4.2	4.8	0.1	–	9.1
NNW	–	2.6	5.3	0.1	–	8.0
TOTALS	2.7	45.3	46.7	5.0	0.3	100.0

a. All values expressed in the form of percent of total time.
b. The data were taken from strip charts that read out in miles per hour. The velocity categories are preselected integer values to bracket each category; therefore, conversion to metric units is not appropriate.

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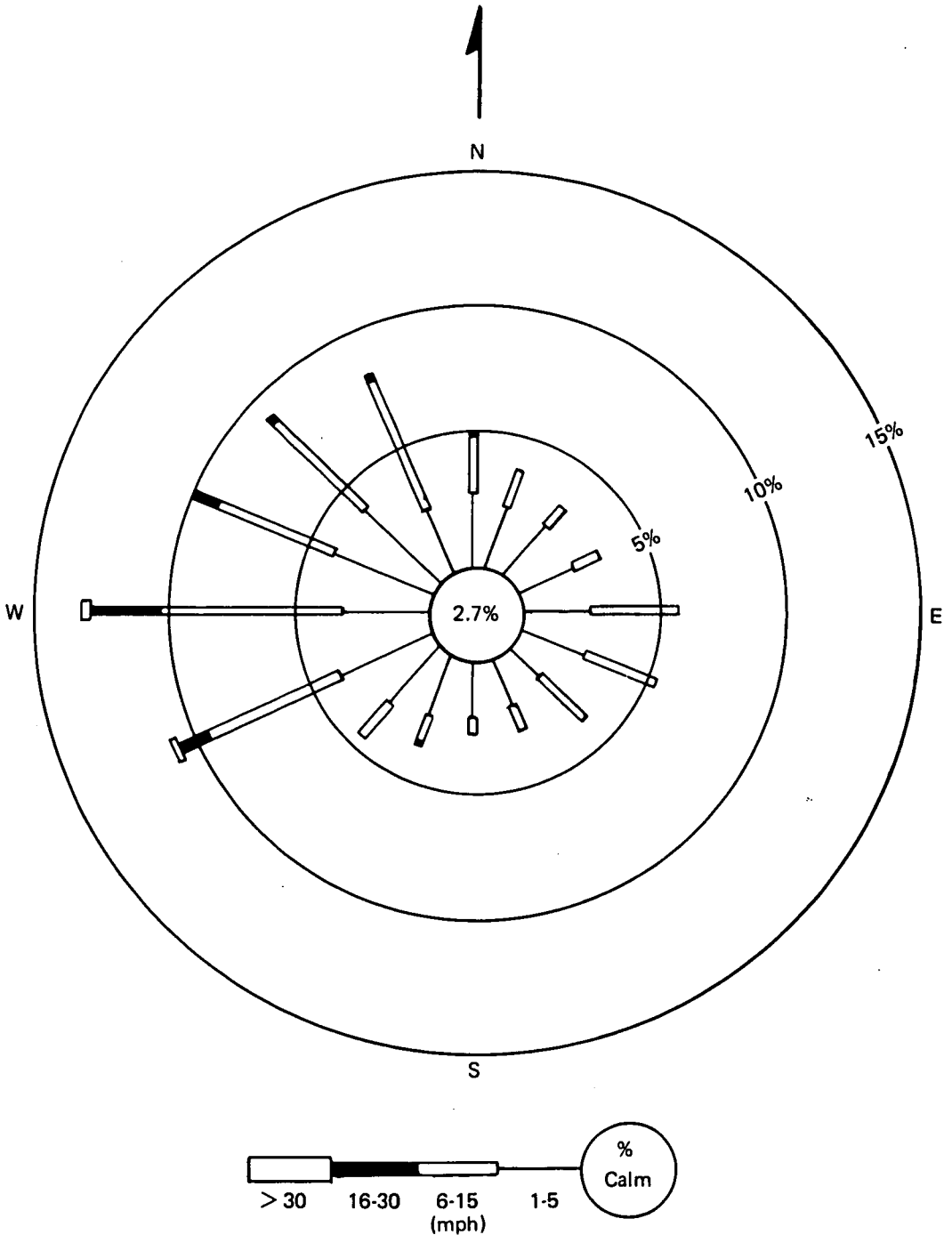
FIGURE 4. 1980 Annual Wind Rose for the Rocky Flats Plant



NOTE: The data were taken from strip charts that read out in miles per hour. The velocity categories are preselected integer values to bracket each category; therefore, conversion to metric units is not appropriate.

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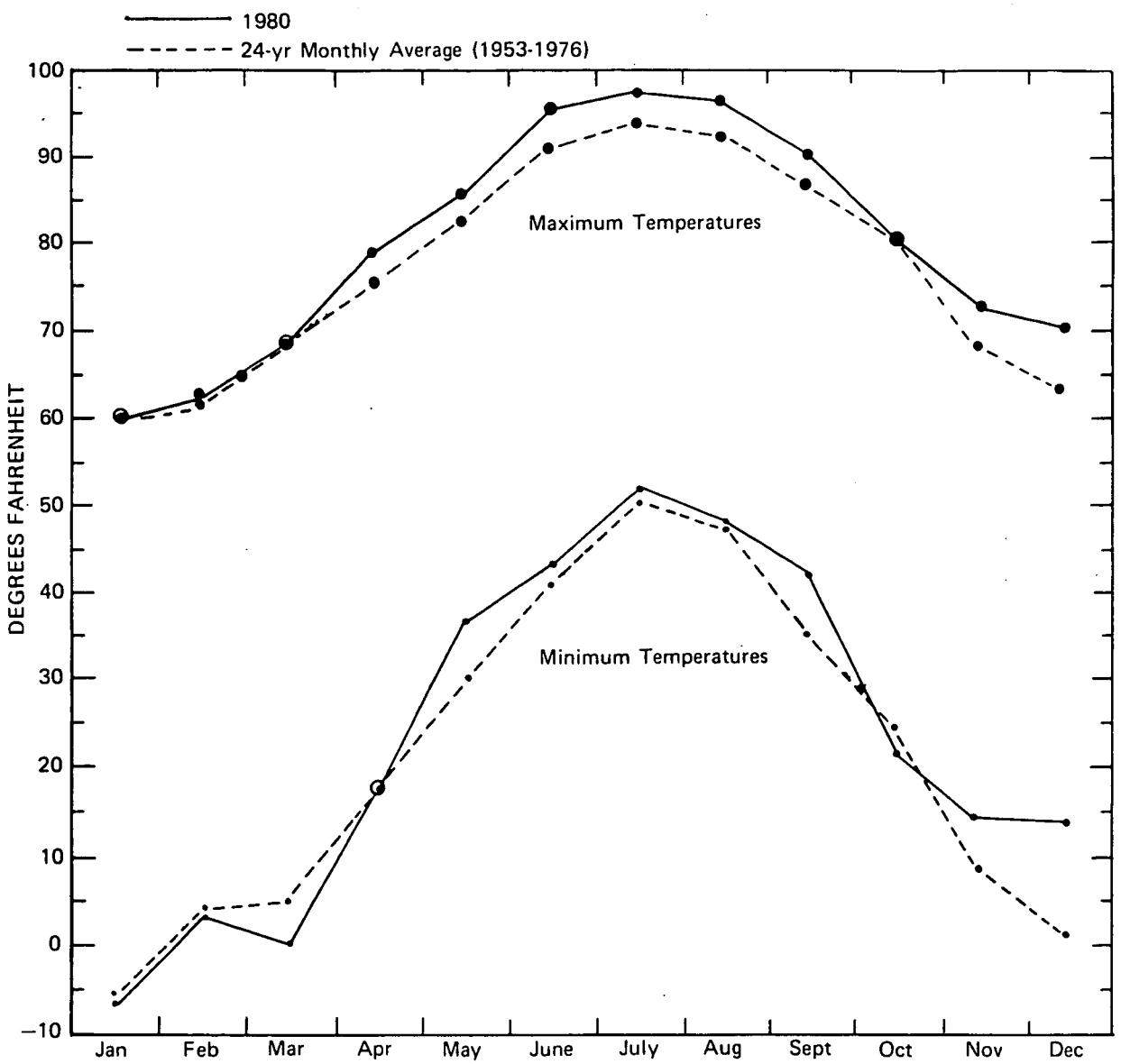

FIGURE 5. Monthly Maximum and Minimum Temperatures, Rocky Flats Plant

summary of the daily maximum and minimum temperatures graphed by the month for 1980 and corresponding 24-year period.

MONITORING SUMMARY

During 1980, the Rocky Flats Plant conducted an environmental monitoring program that included the sampling and analysis of airborne effluents, ambient air, water, soil, and vegetation. External penetrating gamma radiation exposure measurements were also taken using thermoluminescent dosimeters. The program consisted of collecting samples at onsite, boundary, and offsite locations. The principal objective was to measure the presence and concentration of radic nuclides of the types utilized in the Rocky Flats production processes. Monitoring for ambient air quality and for biocides, herbicides, and polychlorinated biphenyls in water also was performed.

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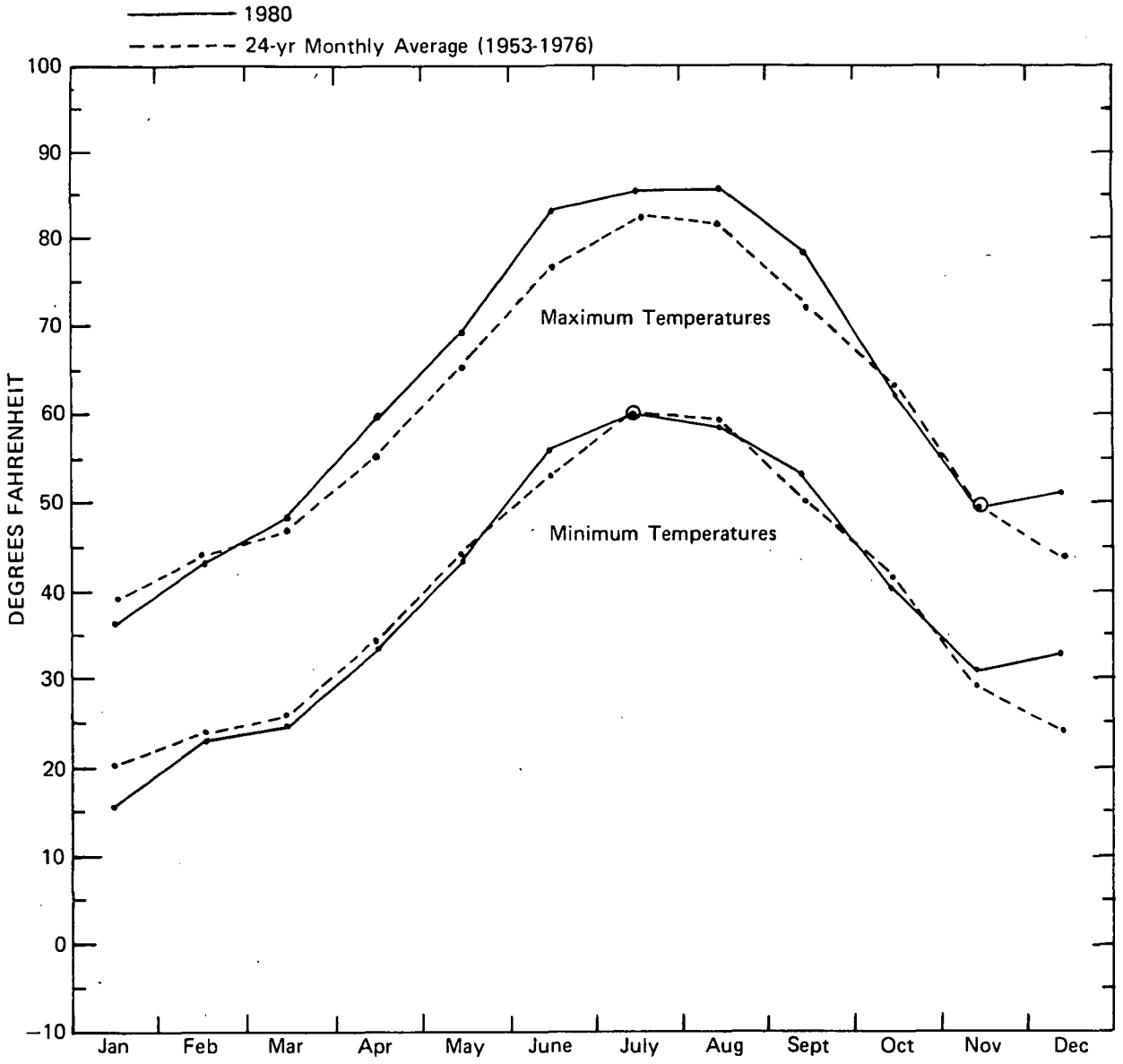

FIGURE 6. Monthly Averages of Daily Maximum and Minimum Temperatures, Rocky Flats Plant

Particulate and tritium sampling of building exhaust systems were conducted continuously. Emission data derived from analysis of these samples were in the ranges normally expected and were not considered to present any significant insult to the environment.

Particulate samples were collected from ambient air samplers operated continuously at onsite, plant perimeter, and nine community locations. Analysis of the samples indicated that the concentrations of airborne plutonium at all locations were far below applicable RCG's.[2,3] At the Plant perimeter and at community locations, the 1980 average plutonium concentrations in ambient air were less than 3.7×10^{-7} Bq/m^3 (0.01×10^{-15} μCi/mℓ).* This value is less than 0.05 percent of the applicable DOE and Colorado Department of Health RCG's[2,3] and less than 1.0 percent of the proposed EPA guidance for plutonium in ambient air.[4]

*1 Bq (becquerel) = $1s^{-1}$ ($\approx 2.7 \times 10^{-11}$ Ci).

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During 1980, some preliminary data were collected to monitor ambient air quality for selected non-radioactive parameters. The program was conducted through the use of a self-contained mobile ambient air monitoring (MAAM) van. Hourly and monthly data were collected for carbon monoxide, nitrogen dioxide, sulfur dioxide, and ozone during the period June to September. These materials are regulated by the EPA in the National Ambient Air Quality Standards (NAAQS).[5] Direct comparison of the four-month data record to air quality limits could not be made as the compliance levels are based on annual sets of data; however, the data generally indicated that the NAAQS air quality compliance levels are being met.

In the past, water discharged from the Plant consisted of storm water runoff and treated sanitary wastewater. In 1980, a program for reuse of the treated sanitary water was implemented, and offsite discharges consisted of storm water runoff only. The treated sanitary wastewater was used for spray-irrigation within the Plant boundaries or was given additional treatment in a new reverse osmosis facility and subsequently reused in Plant cooling towers.

All discharges to offsite receiving waters were measured for compliance with the EPA National Pollutant Discharge Elimination System (NPDES) permit.[6] There were no NPDES violations during 1980.

Routine water monitoring was conducted for two downstream reservoirs and for drinking water in nine communities. The average radioactivity concentrations for plutonium, uranium, americium, and tritium measured at these locations were found to be less than 0.10 percent of the applicable RCG's.[2, 3] In addition, the sum of the average concentrations for plutonium and americium in all community drinking water samples was less than 0.33 percent of the State of Colorado regulations for alpha-emitting radionuclides[3] and the EPA National Interim Primary Drinking Water Regulations.[7] Average concentrations of tritium in community drinking water samples were all within local background range and were less than 2.5 percent of the applicable State of Colorado and EPA drinking water standards.[3, 14]

Groundwater monitoring was conducted three times during 1980 at 42 sampling locations. Tritium and/or uranium have been detected at low concentrations in test holes close to solar evaporation ponds that have been used to store process wastewater. The concentrations of plutonium, uranium, americium, and tritium at all locations were well below the DOE and Colorado Department of Health RCG's for surface water discharged to uncontrolled areas.[2, 3]

Biocides and herbicides are used for pest and weed control at the Rocky Flats Plant. Water samples collected during the period of application indicated concentrations of the chemicals well below recommended concentration limits. Also, polychlorinated biphenyl (PCB) monitoring showed no detectable concentrations above a lower detection limit of one part per million.

A modified soil sampling program implemented in 1979 was continued through 1980. The program involves taking samples from locations west of Indiana Street within the eastern boundaries of the Plant. The purpose of the program is to provide information on the possible migration of plutonium and to provide data for comparison with EPA proposed guidance on transuranium elements in the environment.[4] The latter phase of the program was initiated in 1979 with the collection of 18 samples. The maximum value of plutonium reported was 9.8×10^8 Bq/km^2 (26 mCi/km^2), which is 13 percent of the EPA proposed guideline for plutonium in soil.[4] Nine additional EPA-type samples collected in 1980 showed similar but lower concentrations of plutonium compared to the 1979 samples. The maximum value measured was 6.9×10^8 Bq/km^2 (19 mCi/km^2), which is 10 percent of the EPA proposed guideline.[4] Fifteen surface samples [5 centimeters (2 inches) deep] and 15 core samples [20 centimeters (8 inches) deep] collected within the Plant security zone showed higher plutonium concentrations than in samples measured near the Plant perimeter. These values, which will be compared to future values for migration evaluation, are all within the range of concentrations determined by the Environmental Measurements Laboratory in 1970.[8]

The 1980 environmental measurement of external penetrating gamma radiation, using thermoluminescent dosimeters (TLD's), showed that the annual dose equivalent at onsite, Plant perimeter, and community locations was within the range of regional background.

Potential public radiation dose commitments, which could have resulted from Plant effluents, were calculated from average radionuclide concentrations measured at the DOE property boundaries and in surrounding communities. Dose assessment for 1980 was conducted for the DOE property (site) boundary, nearby communities, and to a distance of 80 kilometers (50 miles). At the Plant boundary, the maximum radiation dose to an individual was calculated to be a 70-year dose commitment of less than 6×10^{-7} Sv* (6×10^{-5} rem) to the total body, and less than 8×10^{-6} Sv (8×10^{-4} rem) to the bone. By comparison, annual doses to the body and bone from natural radiation in the Denver area are 1.50×10^{-3} and 1.68×10^{-3} Sv (0.15 and 0.17 rem) per year, respectively.[9] The 70-year dose commitments of less than 6×10^{-7} Sv and less than 8×10^{-6} Sv represent less than 0.01 percent and less than 0.05 percent, respectively, of the DOE radiation protection standards.[2]

For community locations, the maximum radiation dose resulted in a 70-year dose commitment of less than 2×10^{-8} Sv (2×10^{-6} rem) to the total body and less than 6×10^{-6} Sv (6×10^{-4} rem) to the bone. These values include contribution from fallout caused by atmospheric weapons testing, and represent less than 0.001 percent and less than 0.1 percent, respectively, of the annual DOE standards[2] based on average dose for a suitable sample of the exposed population. The 70-year total body dose commitment to the population living within 80 kilometers (50 miles) of the Plant was based on community dose values. On this basis, the total body and bone doses for all individuals within 80 kilometers are estimated to be less than 4×10^{-2} and 1.2×10^{1} man-sieverts (4 and 1200 man-rem), respectively. For comparison, the corresponding doses from natural radiation background[9] are 3×10^{3} man-sieverts and 3.3×10^{3} man-sieverts (3×10^{5} and 3.3×10^{5} man-rem), respectively.

*1 Sv (sievert) = 1 J kg^{-1} = 100 rem.

MONITORING DATA: COLLECTION, ANALYSES, AND EVALUATION

This section of the report describes the environmental monitoring program for 1980, results of sample analysis, and evaluation of the data with regard to applicable guides and standards. The reader is directed to the appendixes at the end of this report for detailed information concerning applicable guides and standards, quality control, analytical procedures, detection limits and error term propagation, and reporting of minimum detectable concentrations and error terms.

Appendix D includes a discussion of the methodology used for reporting measurements that were at or below the minimum detectable concentrations (MDC). Appendix E explains the use of the less-than sign (<) and the presentation of plus or minus (±) error terms in the data reported.

Airborne Effluent Monitoring

Production and research facilities at Rocky Flats are equipped with 37 ventilation exhaust systems. Particulates, including plutonium and uranium, generated by production and research activities are entrained by exhaust air streams. These particulate materials are removed from the air stream in each exhaust system by means of High Efficiency Particulate Air (HEPA) filters. Residual particulates in each of these systems are continuously sampled downstream from the final stage of the HEPA filters. For immediate detection of abnormal conditions, ventilation systems that service areas containing plutonium are equipped with selective alpha air monitors. These monitors are sensitive to specific radionuclides, including plutonium-239 and -240 and are tested and calibrated routinely to maintain sensitivity. The monitors alarm automatically if out-of-tolerance conditions are experienced. No such conditions occurred during 1980.

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Three times each week, particulate samples are collected and radiometrically analyzed for long-lived alpha emitters. Concentrations of long-lived alpha emitters are indicative of the effluent quality and the overall efficiency of the filtration systems. If the total long-lived alpha concentration for an effluent sample exceeds the Plant action guide value of 7.4×10^{-4} Bq/m^3 (0.02 pCi/m^3), a follow-up investigation is conducted to determine the cause and to establish corrective action.

At the end of each month, samples from each ventilation system are composited into a single sample for dissolution. An aliquot of each of the dissolved, composite samples from the 37 Plant exhaust systems is analyzed for beryllium particulates using a flameless atomic absorption spectrometry technique.[10] The remainder of the dissolved sample undergoes chemical separation and subsequent alpha spectral analysis to quantify specific alpha-emitting radionuclides. Analyses for uranium isotopes are conducted on the composite samples from each of the 37 exhaust systems.

Twenty-eight of the ventilation exhaust systems are located in buildings that contain plutonium. Particulate samples from these 28 systems are also analyzed for specific isotopes of plutonium.

Continuous sampling for tritium is conducted in 15 ventilation exhaust systems. A bubbler-type sampler is used to collect samples three times each week. Tritium concentrations in the sample are measured on a liquid scintillation photospectrometer.

Table 2 presents the quantitative data for radioisotopes in airborne effluents during 1980. These values include contributions from background radioactivity.

During 1980 the total quantity of plutonium released to the atmosphere from 28 ventilation exhaust systems was less than 4.385×10^5 Bq (11.85 μCi). The total discharge of uranium from 37 exhaust stystems was less than 1.101×10^6 Bq (29.76 μCi). Less than 3.12×10^{10} Bq (0.842 Ci) of tritium was released from 15 ventilation systems.

TABLE 2. Radioisotopes in Airborne Effluents

Sample Period	Plutonium[a]			Uranium[b]			Tritium		
	Number of Analyses	Total Discharge (μCi)	C_{max}[c] ($\times 10^{-12}$ μCi/mℓ)	Number of Analyses	Total Discharge (μCi)	C_{max}[c] ($\times 10^{-12}$ μCi/mℓ)	Number of Analyses	Total Discharge (Ci)	C_{max}[c] ($\times 10^{-12}$ μCi/mℓ)
January	35	< 1.90	0.013 ± 0.002	46	1.34	0.170 ± 0.008	180	< 0.087	750 ± 80
February	33	< 0.14	0.0010 ± 0.0002	43	1.18	0.0080 ± 0.0003	195	< 0.063	418 ± 30
March	38	< 0.54	0.0043 ± 0.0004	48	< 8.94	0.096 ± 0.005	195	< 0.089	900 ± 200
April	36	< 0.81	0.002 ± 0.001	45	< 2.26	< 0.054	195	< 0.076	550 ± 60
May	33	< 0.85	0.074 ± 0.003	43	< 1.99	< 0.061	195	< 0.071	500 ± 60
June	31	< 0.76	0.0020 ± 0.0005	39	2.41	0.0172 ± 0.0004	195	< 0.067	670 ± 80
July	33	< 1.32	0.063 ± 0.009	41	< 2.26	0.22 ± 0.01	195	< 0.065	4130 ± 320
August	31	< 0.44	0.0011 ± 0.0001	41	< 2.10	< 0.05	195	< 0.062	1120 ± 90
September	31	< 0.44	0.013 ± 0.001	39	< 2.43	0.0124 ± 0.007	195	< 0.059	670 ± 70
October	32	< 1.75	0.085 ± 0.001	40	< 1.63	0.007 ± 0.001	210	< 0.059	470 ± 60
November	33	< 0.96[d]	0.032 ± 0.002	41	< 1.33	0.0066 ± 0.0005	195	< 0.094	1800 ± 100
December	31	< 1.94	0.031 ± 0.001	39	< 1.89	0.012 ± 0.001	165	< 0.050	3700 ± 400
Summary	397	< 11.85	0.085 ± 0.001	505	< 29.76	0.22 ± 0.01	2310	< 0.842	4130 ± 320

a. Radiochemically determined as plutonium-239, -240.
b. Radiochemically determined as uranium-233, -234, and -238.
c. C_{max} is the maximum measured concentration.
d. This value includes estimated discharges from two exhaust systems for which the sample analyses did not meet quality acceptance criteria. The estimates were based on the average concentration in each system for the previous six months.

TABLE 3. Beryllium in Airborne Effluents

Sample Period	Number of Analyses	Total Discharge* (g)	C_{max} ($\mu g/m^3$)
January	46	< 0.306	0.001
February	43	< 0.179	0.001
March	48	< 0.147	0.003
April	45	< 0.036	< 0.0004
May	43	< 0.025	< 0.0004
June	39	< 0.103	0.0005
July	41	< 0.035	< 0.0004
August	41	< 0.106	0.002
September	39	< 0.069	0.0002
October	40	< 0.044	0.0004
November	41	< 0.041	0.0007
December	39	< 0.043	0.0002
Summary	505	< 1.134	0.003

*The beryllium stationary source emission standard is no more than 10 grams of beryllium over a 24-hour period under the provision in subpart C of 40 CFR 61.32(a).[11]

Table 3 presents the beryllium airborne effluent data for 1980. The total quantity of beryllium released from the 37 ventilation exhaust systems was less than 1.134 g.

Radioactive Ambient Air Monitoring

High-volume ambient air samplers are located on the Rocky Flats Plant site, at the Plant perimeter [at a distance of approximately 3 to 6 kilometers (2 to 4 miles) from the Plant center], and in surrounding communities. The air samplers are of a Rocky Flats design, which is described in detail in Rockwell Engineering Drawings 27261-1 through 27261-6. The high-volume samplers operate continuously at a volume flow rate of approximately 19 ℓ/sec (40 ft^3/min), and particulates are collected on a 20- X 25-centimeter (8- X 10-inch) Delbag Microsorban® filter media. The effectiveness of the high-volume sampler and the filter media has been evaluated by Dr. James B. Wedding of Colorado State University.[12] According to Wedding, the Rocky Flats design compared favorably to the EPA-specified standard Hi-Volume Sampler for a variety of simulated field conditions. The filter media was found to be greater than 99.9 percent efficient for particle sizes and pressure drops typical of conditions encountered in routine ambient air sampling.

®Trademark of Delbag-Luftfilter, Berlin, Germany.

Airborne particulates in ambient air are sampled continuously at 23 locations within and adjacent to the Rocky Flats exclusion area (Figure 7). The sample filters are collected weekly and analyzed for total long-lived alpha (TLLα). If TLLα concentration for an ambient air sample exceeds a Plant guide value [3.7×10^{-4} Bq/m^3 (0.01 pCi/m^3)] specific plutonium analysis is performed. During 1980, all TLLα concentrations were less than the guide value.

On a routine basis, filters from 9 of the 23 samplers are composited and analyzed biweekly for plutonium. Table 4 contains the average concentrations of plutonium in ambient air at these nine onsite stations during 1980. The average concentrations of plutonium in ambient air at the nine onsite stations during 1980 ranged from less than 7.4×10^{-7} to 1.7×10^{-5} Bq/m^3 (0.02×10^{-15} to 0.45×10^{-15} μCi/mℓ). These concentrations were less than 0.76 percent of the RCG_a for soluble plutonium in ambient air in uncontrolled areas.[2, 3]

Monitoring for tritium in ambient air water vapor is conducted at onsite locations S-4, S-5, and S-16 (Figure 7). Samples are collected and analyzed weekly. The tritium sampler includes a 1 ℓ/m air pump that operates continuously. The pump is powered by a 12V d.c. regulated power supply, and the sample is collected in a Pyrex tube filled with silica gel, which collects moisture from the ambient air. This equipment is contained in an aluminum case that is insulated, weathertight, and lockable. Temperature inside the case is controlled by a small heater and fan that maintains a temperature between 4.44 and 32.2 °C (40 and 90 °F). Table 5 presents the average concentrations of tritium in ambient air water vapor at these three onsite stations for 1980. The average concentration of tritium in ambient air at the three onsite stations during 1980 was less than 1.9×10^1 Bq/ℓ ($< 500 \times 10^{-9}$ μCi/mℓ). This concentration

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FIGURE 7. Location of Onsite Ambient Air Samplers

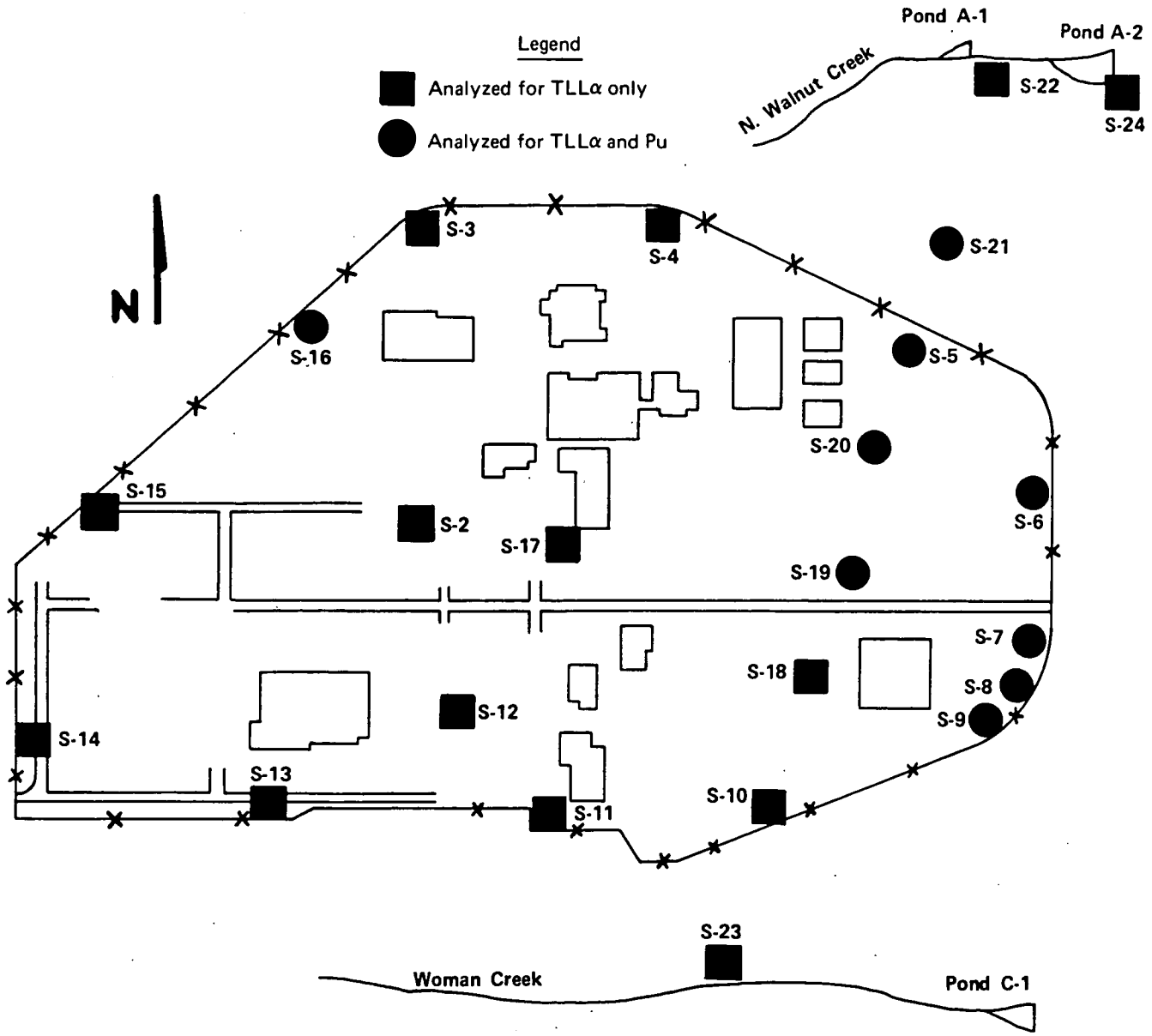

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TABLE 4. Plutonium-239 and -240 Activity Concentrations in Onsite Ambient Air at Selected Locations

Station[b]	Number of Analyses	Less Than Detectable	Volume (X 1,000 m^3)	Concentration[a] (X 10^{-15} μCi/mℓ)			Percent of RCG_a[c]
				C_{min}	C_{max}	C_{avg}	
S-5	25	1	421	< 0.01	0.22	< 0.06	< 0.10
S-6	25	0	428	0.01	0.29	0.07 ± 0.01	0.12
S-7	25	0	396	0.03	1.81	0.27 ± 0.01	0.45
S-8	25	0	408	0.05	2.16	0.41 ± 0.01	0.68
S-9	25	0	434	0.10	1.84	0.45 ± 0.01	0.75
S-16	25	9	421	< 0.01	0.08	< 0.02	0.03
S-19	25	2	447	< 0.01	0.11	< 0.03	< 0.03
S-20	25	3	380	< 0.01	0.08	< 0.03	< 0.05
S-21	25	9	436	< 0.01	0.29	< 0.03	< 0.05
Summary	225	24	3771	< 0.01	2.16		

a. Two-week composites of station concentrations.
b. These selected air-sampling locations are in the proximity of areas where there is a potential for airborne activity. See Figure 7.
c. The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air in uncontrolled areas is 60 X 10^{-15} μCi/mℓ.

TABLE 5. Tritium Activity Concentration in Onsite Ambient Air Water Vapor

Station	Number of Analyses	Concentration (X 10^{-9} μCi/mℓ)			Percent of RCG_w[b]
		C_{min}	C_{max}	C_{avg}[a]	
S-4	42	< 300	1000	< 500	< 0.05
S-5	43	< 300	1500	< 500	< 0.05
S-16	40	< 300	900	< 500	< 0.05

a. The average tritium concentration is less than 2.5 percent of the state of Colorado primary drinking water limit of 20,000 X 10^{-9} μCi/mℓ.
b. The Radioactivity Concentration Guide (RCG_w) for tritium in water released to uncontrolled areas is 1,000,000 X 10^{-9} μCi/mℓ.

was less than 0.05 percent of the RCG_W for tritium in water released to uncontrolled areas.[2, 3]

Samples of airborne particulates are collected on filters by high-volume air samplers at 14 locations along or near the Plant perimeter. These perimeter samplers are located between 3 and 6 kilometers (2 and 4 miles) from the Plant center. (See Figure 8). The samplers are numbered S-31 through S-44. Samples from each location are collected weekly, composited by location, and analyzed for a four-week period for plutonium. Table 6 presents the average concentrations of plutonium radioactivity in airborne particulates at Stations S-31 through S-44 during 1980. The average concentration of plutonium in ambient air at these locations during 1980 was less than 3.7 X 10^{-7} Bq/m^3 (0.01 X 10^{-15} μCi/mℓ). This concentration was less than

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FIGURE 8. Location of Offsite Ambient Air Samplers

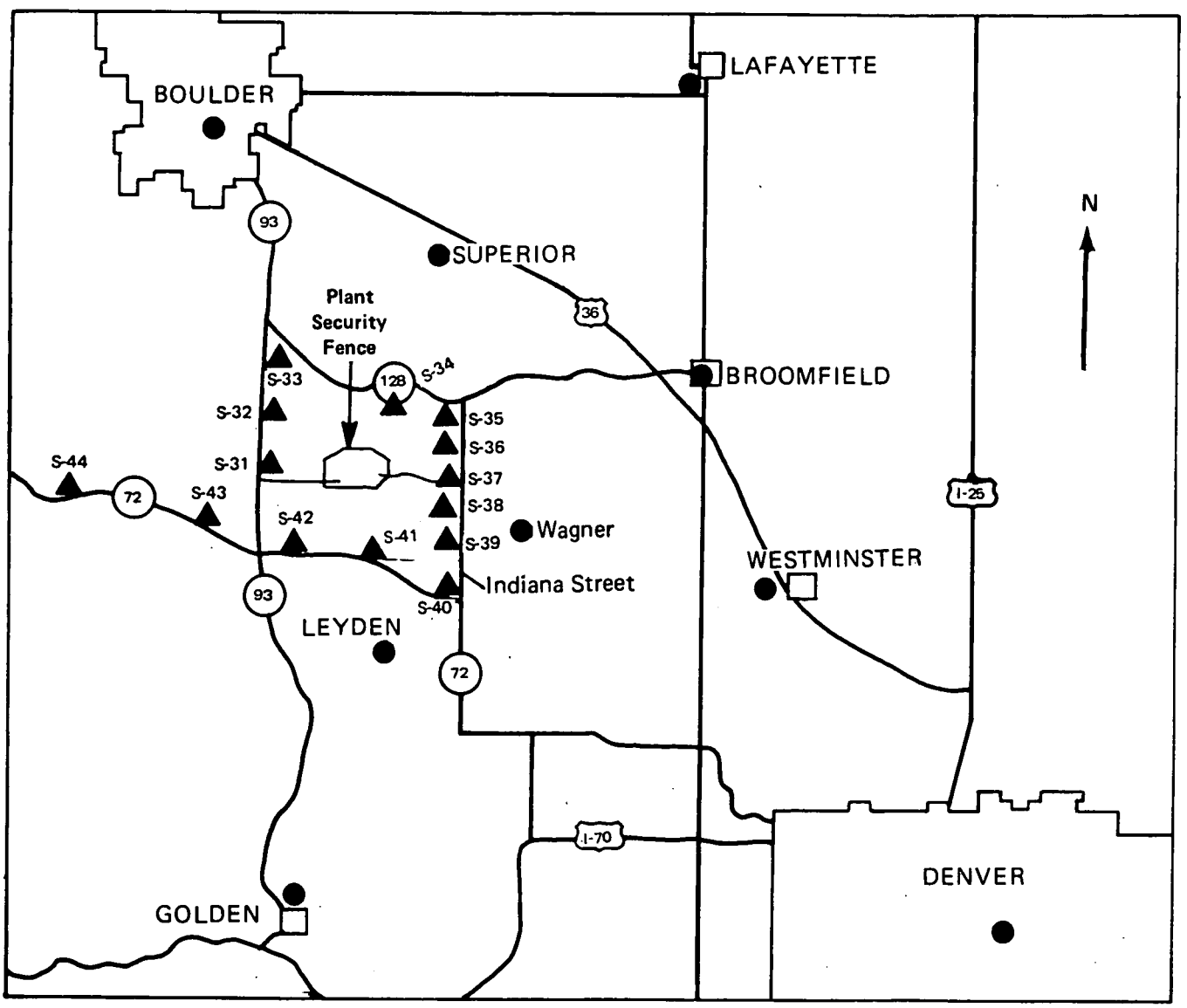

TABLE 6. Plutonium-239 and -240 Activity Concentration in Perimeter Ambient Air
[3 to 6 kilometers (2 to 4 miles) from Rocky Flats]

Station	Number of Analyses	Less Than Detectable	Volume (× 1,000 m³)	Concentration (× 10^{-15} μCi/mℓ)			Percent of RCG_a*
				C_{min}	C_{max}	C_{avg}	
S-31	13	4	453	< 0.01	0.02	< 0.01	< 0.05
S-32	13	5	502	< 0.01	0.02	< 0.01	< 0.05
S-33	13	2	496	< 0.01	0.02	< 0.01	< 0.05
S-34	13	4	484	< 0.01	0.02	< 0.01	< 0.05
S-35	13	4	463	< 0.01	0.02	< 0.01	< 0.05
S-36	13	5	449	< 0.01	0.03	< 0.01	< 0.05
S-37	13	1	491	< 0.01	0.03	< 0.01	< 0.05
S-38	13	3	463	< 0.01	0.02	< 0.01	< 0.05
S-39	13	3	468	< 0.01	0.02	< 0.01	< 0.05
S-40	13	4	477	< 0.01	0.02	< 0.01	< 0.05
S-41	13	5	453	< 0.01	0.02	< 0.01	< 0.05
S-42	13	6	496	< 0.01	0.02	< 0.01	< 0.05
S-43	13	3	491	< 0.01	0.02	< 0.01	< 0.05
S-44	13	5	478	< 0.01	0.02	< 0.01	< 0.05
Summary	182	54	6664	< 0.01	0.03		
Average Concentration						< 0.01	< 0.05

*The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air available to the general population is 20 × 10^{-15} μCi/mℓ.

0.05 percent of the soluble plutonium RCG_a for the general population.[2, 3]

Samples of airborne particulates are also collected at nine locations in or near communities in the vicinity of the Rocky Flats Plant. These locations, as identified in Figure 8, are Boulder, Broomfield, Denver, Golden, Lafayette, Leyden, Superior, Wagner, and Westminster. Sample filters from these sites are collected weekly, composited by location, and analyzed for a four-week period for plutonium alpha activity.

Table 7 presents the average concentrations of plutonium in airborne particulates at the community stations during 1980. The average plutonium concentration in ambient air at the community stations was less than 3.7 × 10^{-7} Bq/m³ (0.01 × 10^{-15} μCi/mℓ). This value is less than 0.05 percent of the soluble plutonium RCG_a for the general population.[2, 3]

Nonradioactive Ambient Air Monitoring

Various operations are conducted at the Rocky Flats Plant that could contribute to air pollution. Possible sources include incineration, spray painting, chemical operations that require the use of nitric acid and various solvents, automobile exhaust emissions, and construction activities that suspend dust.

During 1980, limited monitoring of ambient air for selected nonradioactive parameters was performed. This program was conducted through utilization of a self-contained van for mobile ambient air monitoring (MAAM). The van is equipped with instruments to measure the concentration of carbon monoxide, total suspended particulates, ozone, oxides of nitrogen, sulfur dioxide, and total nonmethane hydrocarbons. These materials are regulated by the Environmental Protection Agency through the National Ambient Air Quality Standards (NAAQS).[5]

TABLE 7. Plutonium-239 and -240 Activity Concentrations in Community Ambient Air

Location	Number of Analyses	Less Than Detectable	Volume (X 1,000 m^3)	Concentration (X 10^{-15} μCi/mℓ)			Percent of RCG_a*
				C_{min}	C_{max}	C_{avg}	
Boulder	13	5	495	< 0.01	0.02	< 0.01	< 0.05
Broomfield	13	2	452	< 0.01	0.05	< 0.02	< 0.10
Denver	13	4	465	< 0.01	0.02	< 0.01	< 0.05
Golden	13	2	440	< 0.01	0.05	< 0.01	< 0.05
Lafayette	13	3	474	< 0.01	0.02	< 0.01	< 0.05
Leyden	13	4	468	< 0.01	0.03	< 0.01	< 0.05
Superior	13	3	440	< 0.01	0.02	< 0.01	< 0.05
Wagner	13	4	431	< 0.01	0.04	< 0.01	< 0.05
Westminster	13	1	469	< 0.01	0.06	< 0.01	< 0.05
Summary	117	28	4134	< 0.01	0.06		
Average Concentration						< 0.01	< 0.05

*The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air available to the general population is 20 X 10^{-15} μCi/mℓ.

TABLE 8. Mobile Ambient Air Monitoring (MAAM) Detection Limits and National Ambient Air Quality Standards (NAAQS)

Parameter	Approximate Minimum Detectable Concentration (ppm)	NAAQS Compliance Level (ppm)
Carbon Monoxide	0.01	35 (1-hr avg)[a] 9 (8-hr avg)[a]
Total Suspended Particulates	no data	75 $\mu g/m^3$ (1-hr avg)[b] 260 $\mu g/m^3$ (24-hr avg)[a]
Ozone	0.0003	0.12 (1-hr avg)[a]
Nitrogen Dioxide	0.0001	0.05 (1-hr avg)[c]
Sulfur Dioxide	0.0001	0.03 (1-hr avg)[c] 0.50 (3-hr avg)[a] 0.14 (24-hr avg)[a]
Total Nonmethane Hydrocarbons[d]	0.1	0.24 [3-hr avg (6-9 a.m.)][a]

a. Not to be exceeded more than once per year.
b. Annual geometric mean.
c. Annual arithmetic mean.
d. This parameter is for use as a guide in devising implementation plans to achieve oxidant standards.

Table 8 gives detection capabilities of MAAM monitoring instruments and lists the corresponding compliance standards.

The van also has a portable tower mounted on the roof with instruments for collecting temperature, wind velocity, and wind direction data. During

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1980, the van was moved to a location near the east entrance to the Plant. This is an open area that is near a traffic zone and is generally downwind from Plant buildings. Start-up of the MAAM instruments was implemented in June 1980 and routine data collection continued for about four months. During the last three months of 1980, numerous instrumentation and data acquisition problems were encountered that prevented the collection of valid data.

Table 9 presents data collected in the summer of 1980 for carbon monoxide, nitrogen dioxide, sulfur dioxide, and ozone. Because of continuing instrument problems, limited carbon monoxide and total nonmethane hydrocarbon data were collected. The accuracy of these data is based on span gas calibration. Each gas was introduced as a known concentration of pollutant to each type of monitoring instrument. This provided a single concentration level, or span point, upscale from a zero level of detection. At best, the data are accurate to within ± 10 percent and represent only an indication of ambient air concentrations at that location.

The data in Table 9 are a summary of the daily records of hourly averages and monthly averages. Because the NAAQS are for annual data, direct comparison for compliance cannot be made; however, the data can be used as a general indicator of air quality. Table 9 shows that the carbon monoxide concentrations for June were well below the NAAQS. The monthly average concentrations for nitrogen dioxide ranged from 0.005 to 0.041 parts per million. For sulfur dioxide, the monthly average concentrations ranged from 0.005 to 0.008 parts per million. Nitrogen dioxide and sulfur dioxide monthly averages for the four-month period indicate that the NAAQS of an annual arithmetic mean concentration of 0.05 and 0.03 parts per million, respectively, would not be exceeded.

The summary data in Table 9 indicate that some of the maximum hourly average concentrations of sulfur dioxide were elevated. A review of all the hourly data for each month indicated, however, that the 3-hour and 24-hour average concentrations would be within the appropriate NAAQS compliance levels. Sulfur dioxide concentrations throughout Colorado are quite low and the State of Colorado does not consider sulfur dioxide to be a problem pollutant.

Ozone concentrations for the period June through September were also within the NAAQS compliance levels. The monthly average concentrations ranged from 0.009 to 0.027 parts per million; the maximum hourly average was 0.062 parts per million. The NAAQS for this latter parameter is not to exceed a one-hour average concentration of 0.12 parts per million more than once in any year.

Total suspended particulate measurements are routinely collected at the Plant boundary by the Colorado Department of Health. Historically these data have been well below the NAAQS, with the yearly averages ranging from about 30 to 66 $\mu g/m^3$.[13]

TABLE 9. Onsite Nonradioactive Ambient Air Quality Data

Sample Period	Carbon Monoxide (ppm)			Nitrogen Dioxide (ppm)			Sulfur Dioxide (ppm)			Ozone (ppm)		
	Hourly Average		Monthly	Hourly Average		Monthly	Hourly Average		Monthly	Hourly Average		Monthly
	C_{min}	C_{max}	C_{avg}	C_{min}	C_{max}	C_{avg}	C_{min}	C_{max}	C_{avg}	C_{min}	C_{max}	C_{avg}
June	0.53	2.40	0.63	0.007	0.185	0.041	0.001	0.034	0.005	0.006	0.061	0.027
July	ND*	ND	ND	0.002	0.229	0.036	0.002	0.064	0.008	0.007	0.062	0.026
August	ND	ND	ND	0.001	0.019	0.005	0.0001	0.028	0.008	0.0003	0.022	0.009
September	ND	ND	ND	0.002	0.229	0.036	0.002	0.064	0.008	0.007	0.062	0.027

*ND means no data; instrument out of service.

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Waterborne Effluent Monitoring

North Walnut Creek receives storm water runoff from the north side of the Plant site. (See Figure 3). Holding Pond A-3 on North Walnut Creek has historically been used to impound this surface runoff for analysis prior to discharge. In addition, a surface water control retention pond, A-4, which serves a broader area, was completed in 1980. Ponds A-1 and A-2 are isolated from North Walnut Creek and are used for storage and evaporation of water containing less than 62 Bq/ℓ ($1{,}667 \times 10^{-9}$ μCi/mℓ) of plutonium.

Wastewater from one Plant cooling tower is pumped to Pond A-2 from Pond B-2. During the summer months, natural evaporation is enhanced by spraying wastewater through fog nozzles over the surfaces of Pond A-1 and A-2. These ponds then receive the excess water that does not evaporate during the process. Typically, the plutonium concentration in this water averages less than 0.2 Bq/ℓ (5×10^{-9} μCi/mℓ).

South Walnut Creek receives discharges from the Plant's advanced sanitary waste treatment facility after passage through Ponds B-3 and B-4. A surface water control retention pond, B-5, was added in the South Walnut Creek drainage during 1980. Surface runoff from the center portion of the Plant site is received by South Walnut Creek. During 1980, none of the treated sanitary wastewater was discharged to South Walnut Creek. The water was spray-irrigated from Pond B-3 onto the Rocky Flats soil or was reused in Plant cooling towers. Wastewater entering the sanitary waste treatment facility consisted of cooling tower blowdown, steam condensate, and sanitary waste. These liquid wastes were subjected to advanced wastewater treatment before being used for spray irrigation. Solids resulting from this treatment were decomposed in an anaerobic digestor. After drying, the contents were packaged and shipped to a DOE-approved facility.

Discharges from the Rocky Flats Plant are monitored for compliance with appropriate Colorado Department of Health standards and EPA NPDES permit limitations.[6] Annual average concentrations of chemical and biological constituents of liquid effluent samples collected from Pond A-3 and Pond C-1 during 1980 are presented in Table 10. The data are indicative of overall water quality from these ponds. The NPDES permit places limitations on daily concentrations and monthly average concentrations for all applicable parameters. There were no violations of the NPDES permit during 1980.

The surface water control system was expanded as a means of improving retention capability in the event the water proves unsuitable for discharge. Construction was completed in 1980 and resulted in additions to the system such as Pond A-4 with a 1.15×10^{8} ℓ (93 acre-feet) capacity on North Walnut Creek, Pond B-5 with a 9.87×10^{7} ℓ (80 acre-feet) capacity on South Walnut Creek, Pond C-2 with a 7.89×10^{7} ℓ (64 acre-feet) capacity on Woman Creek, an interceptor canal that will collect surface runoff from the southern part of the Plant site and route it to Pond C-2, diversion of upstream surface runoff from the Woman Creek drainage around Pond C-2, and the McKay Ditch Bypass Canal and related facilities for diverting upstream runoff and flows in the North Walnut Creek drainage around the Plant site. The diversion system and the retention ponds are designed to handle the expected surface runoff from a 1-in-100 year, 3-day rainfall event of 15.5 centimeters (6.1 inches). Ponds A-4, B-5, and C-2 have standpipes connected to the outlet structure for the purpose of minimizing the amount of sediment discharged downstream. Periodically, pools that collect these sediments will be dredged. Disposition of the sediments will depend upon their chemical and radiological composition, as indicated by sample analysis.

Prior to discharge from Ponds A-4, B-5, and C-2, the water is sampled and analyzed for gross alpha, gross beta, tritium, and gamma activity; pH; nitrate as N; and nonvolatile suspended solids. The water will not be discharged if the Plant action level for any parameter is exceeded.

During planned discharges from Pond A-3 in 1980, the water was sampled continuously. Those samples were analyzed for plutonium, uranium, americium, and tritium. Water is also sampled continuously and collected daily from the outfalls of Ponds B-4 and C-1, and from Walnut Creek at

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TABLE 10. Annual Average Concentrations of Chemical and Biological Constituents in Liquid Effluents

Parameter	Number of Analyses	C_{min}	C_{max}	C_{avg}
Discharge Point 001[a]				
During 1980, no discharges were made to offsite waters.				
Discharge Point 002[a]				
pH	28	7.4 SU[b]	8.8 SU	8.0 SU
Nitrate as N	28	< 1.0 mg/ℓ	16 mg/ℓ	< 7.0 mg/ℓ
Discharge Point 003[a]				
pH	24	7.3 SU	8.7 SU	7.9 SU
Nitrate as N	12	< 0.2 mg/ℓ	1.0 mg/ℓ	< 0.5 mg/ℓ
Total Dissolved Solids	24	76 mg/ℓ	315 mg/ℓ	185 mg/ℓ
Chemical Oxygen Demand	12	< 1.0 mg/ℓ	26.0 mg/ℓ	< 13.0 mg/ℓ

a. The Environmental Protection Agency NPDES discharge permit defines Discharge Points 001, 002, and 003 as the sewage treatment plant, Pond A-3, and Pond C-1, respectively.
b. SU - Standard Unit.

TABLE 11. Plutonium, Uranium, and Americium Activity Concentrations in Rocky Flats Ponds

Location	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_W
		Plutonium Concentration ($\times 10^{-9}$ μCi/mℓ)[a]			
Pond A-3	28	< 0.04	0.22 ± 0.04	< 0.06	< 0.01
Pond B-4	53	0.01 ± 0.01	0.40 ± 0.02	< 0.09	< 0.01
Pond C-1	53	0.004 ± 0.005	< 0.07	< 0.01	< 0.01
		Uranium Concentration ($\times 10^{-9}$ μCi/mℓ)[b]			
Pond A-3	28	< 1.0	9.6 ± 0.5	< 4.0	< 0.04
Pond B-4	53	0.99 ± 0.03	15 ± 3	< 7.0	< 0.07
Pond C-1	53	< 0.1	< 11	< 3.0	< 0.03
		Americium Concentration ($\times 10^{-9}$ μCi/mℓ)[c]			
Pond A-3	28	< 0.01	0.16 ± 0.08	< 0.07	< 0.01
Pond B-4	53	< 0.001	0.22 ± 0.01	< 0.05	< 0.01
Pond C-1	53	< 0.001	0.09 ± 0.03	< 0.03	< 0.01

a. Radiochemically determined as plutonium-239, and -240. The Radioactivity Concentration Guide (RCG_W) for soluble plutonium in water is 1667×10^{-9} μCi/mℓ.
b. Radiochemically determined as uranium-233, -234, and -238. The most restrictive RCG_W for these insoluble uranium isotopes is $10{,}000 \times 10^{-9}$ μCi/mℓ.
c. Radiochemically determined as americium-241. The RCG_W for soluble americium-241 is 1330×10^{-9} μCi/mℓ.

Indiana Street. These daily samples are composited into weekly samples for plutonium, uranium, and americium analyses. Once each week, daily samples at each location are analyzed for tritium. Concentrations of plutonium, uranium, americium, and tritium in water samples at the outfalls of Ponds A-3, B-4, C-1, and from Walnut Creek at Indiana Street are presented in Tables 11, 12, and 13.

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TABLE 12. Plutonium, Uranium, and Americium Activity Concentrations in Walnut Creek

Location	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_W
		Plutonium Concentration ($\times 10^{-9}$ μCi/mℓ)[a]			
Walnut Creek at Indiana Street	32	< 0.008	< 0.1	< 0.03	< 0.01
		Uranium Concentration ($\times 10^{-9}$ μCi/mℓ)[b]			
Walnut Creek at Indiana Street	32	< 1.0	14 ± 3	< 6.0	< 0.06
		Americium Concentration ($\times 10^{-9}$ μCi/mℓ)[c]			
Walnut Creek at Indiana Street	32	< 0.002	< 0.1	< 0.03	< 0.01

a. Radiochemically determined as plutonium-239, and -240. The Radioactivity Concentration Guide (RCG_W) for soluble plutonium in water is 1667×10^{-9} μCi/mℓ.
b. Radiochemically determined as uranium-233, -234, and -238. The most restrictive RCG_W for these insoluble uranium isotopes is $10{,}000 \times 10^{-9}$ μCi/mℓ.
c. Radiochemically determined as americium-241. The RCG_W for soluble americium-241 is 1330×10^{-9} μCi/mℓ.

TABLE 13. Tritium Activity Concentrations in Plant-Site Waters

Plant-Site Waters	Number of Analyses	Concentration ($\times 10^{-9}$ μCi/mℓ) C_{min}	C_{max}	C_{avg}	Percent of RCG_W[a]
Pond A-3	28	< 400	1100 ± 700	< 600	< 0.06
Pond B-4	53	< 400	1400 ± 800	< 600	< 0.06
Pond C-1	53	< 400	1200 ± 600	< 600	< 0.06
Walnut Creek at Indiana Street	32	< 400	1300 ± 600	< 700	< 0.07

a. The Radioactivity Concentration Guide (RCG_W) for tritium in water released to uncontrolled areas is $1{,}000{,}000 \times 10^{-9}$ μCi/mℓ.

All plutonium, uranium, americium, and tritium concentrations at these locations were less than 0.07 percent of the applicable Radioactivity Concentration Guides (RCG_W).[2, 3]

The Rocky Flats Plant water supply was taken from two sources during the year—Ralston Reservoir and South Boulder Diversion Canal. Ralston Reservoir is located near the Schwartzwalder uranium mine and the water usually contains more uranium activity than does water from the South Boulder Diversion Canal, which flows from the Moffat Tunnel. Throughout the year, weekly uranium analyses were performed on samples of Rocky Flats raw and treated water. The uranium concentrations measured during 1980 are presented in Table 14. Uranium concentrations measured during 1980 in raw and treated water averaged less than 0.34 and 0.28 Bq/ℓ (9.3×10^{-9} and 7.6×10^{-9} μCi/mℓ), respectively. This water was used throughout the Plant, discharged to the sanitary sewage system, and ultimately was spray-irrigated from Pond B-3 or reused in Plant cooling towers.

Biocides and herbicides are used in pest and weed control on the Rocky Flats Plant site. Pest and

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TABLE 14. Uranium Activity Concentrations in Rocky Flats Raw and Treated Water

Water Source	Number of Analyses	C_{min}*	C_{max}*	C_{avg}*
Raw Water				
Ralston Reservoir	20	3.0 ± 0.1	33 ± 2	16.1 ± 0.4
South Boulder Diversion Canal	31	0.9 ± 0.1	17 ± 1	< 4.9
Summary	51			< 9.3
Treated Water				
Ralston Reservoir	20	1.1 ± 0.1	28 ± 1	< 11.4
South Boulder Diversion Canal	31	< 0.4	26 ± 1	< 5.1
Summary	51			< 7.6

NOTE: Uranium concentrations radiochemically determined as uranium-233, -234, and -238.

*Uranium concentration values ($\times 10^{-9}$ μCi/mℓ).

weed control actions are coordinated with the Jefferson County Extension Service and the Colorado State Department of Agriculture. Plans for application of pesticides and herbicides are prepared in accordance with guidelines issued by the Federal Working Group on Pest Management. Water samples are collected from Ponds B-4 and C-1 during the period of application. Analytical results for 2,4-D and bromacil have consistently been less than 2 parts per billion. The recommended concentration limit is 100 parts per billion.

Polychlorinated biphenyls (PCB's) are stored at the Rocky Flats Plant and are present in some transformer oils. Analytical results from downstream waters showed no detectable concentrations of PCB's above a minimum detectable concentration of approximately one part per million.

Groundwater Monitoring

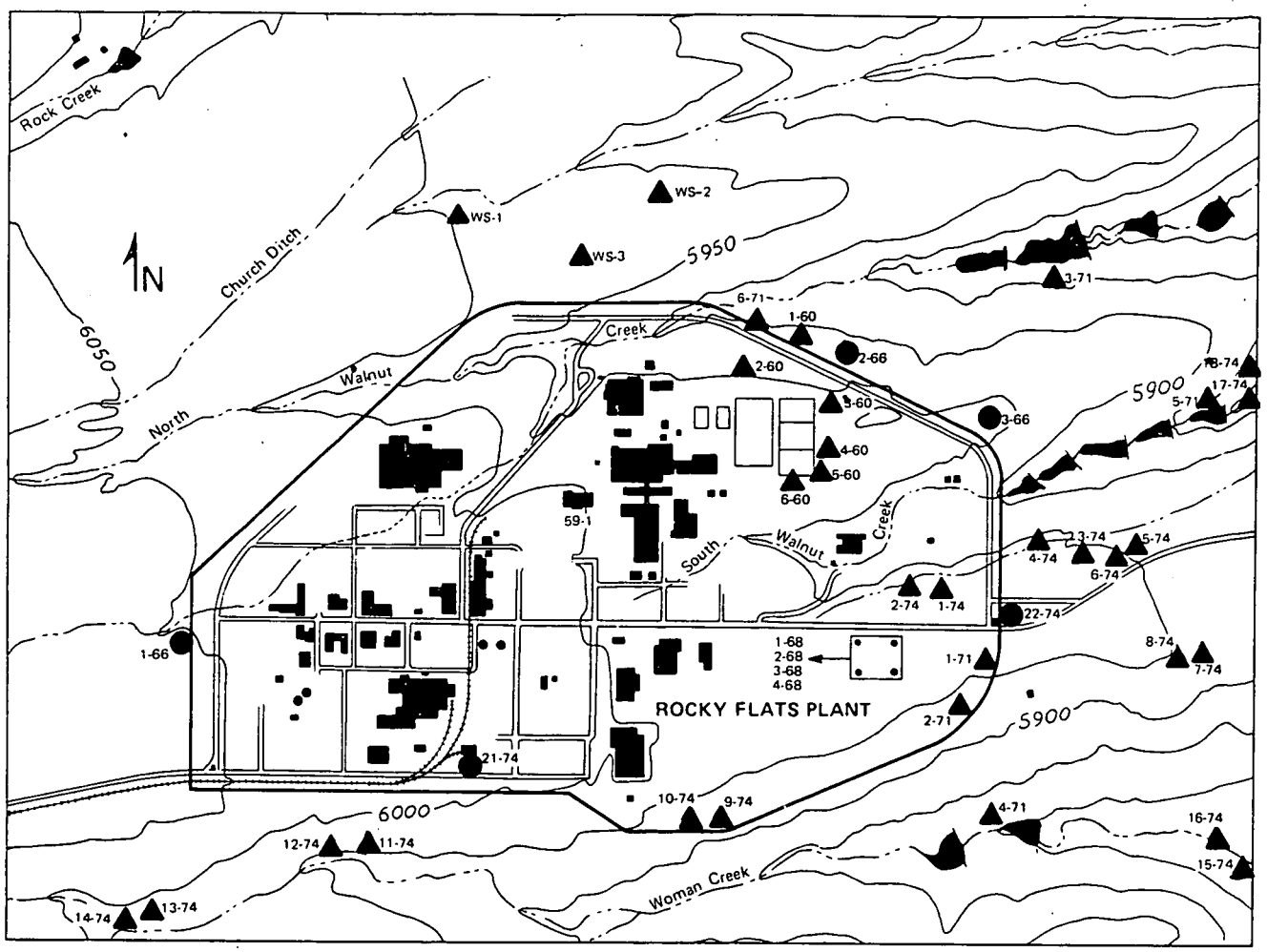
In April, June, and September, 42 groundwater monitoring test holes were sampled. Analyses of these samples were conducted to determine if there was any movement of chemical or radioactive materials of possible Plant origin into water-bearing strata underlying the site.

Five of the monitoring test holes range from 43 to 96 meters (140 to 320 feet) in depth. These test holes, numbered 1-66, 2-66, 3-66, 21-74, and 22-74, are located, respectively, west of the west security fence, northeast of the solar ponds, east of the solar ponds, near the south security fence and east of the east security fence. These test holes provide information concerning water quality in gravel and bedrock formations. The remaining test holes range from 1 to 15 meters (3 to 50 feet) deep and generally are located near three onsite solar evaporation ponds, other holding ponds, and old trash burial sites. Locations of all 42 monitoring test holes are identified in Figure 9.

The sampled water from the test holes was analyzed for plutonium, uranium, americium, and tritium. Table 15 presents measured depths of the holes and radioactivity concentrations for water obtained from each test hole during 1980.

Tritium and/or uranium have been detected at low concentrations in test holes close to solar evaporation ponds that have been used to store process wastewater prior to treatment. These ponds are hydrologically upgradient from the test holes and some seepage has occurred. A new facility has been completed to treat these process wastewaters. Three of the solar ponds have been cleaned and one has been completely relined.

Two test holes located immediately east and downstream from Pond B-4 were found to contain



Legend

● Test hole depth greater than 30 meters

▲ Test hole depth less than 15 meters

FIGURE 9. Location of Groundwater Monitoring Test Holes

higher than normal uranium concentrations. The concentrations of plutonium, americium, and tritium were normal. The uranium may be natural material and not of Rocky Flats Plant origin. Small pockets of low grade uranium ore are not uncommon in the Arapahoe bedrock formation, which underlies the Plant.

For the first time since sampling began on the 68-series test holes, water was found in two of them. Test holes 1-68 and 2-68 had water in them in April. No plutonium, uranium, or americium was detected in the samples from these two test holes, and the tritium concentrations were within the range of regional background.

There are no applicable RCG's for groundwater; however, for perspective, the concentrations of plutonium, uranium, americium, and tritium in all samples were well below the DOE and Colorado Department of Health RCG's for water discharged to uncontrolled areas.[2, 3]

Regional Water Monitoring

Water samples were collected weekly from Great Western Reservoir, a water supply for the city of Broomfield, and from Standley Lake, a water supply for the city of Westminster and portions of the Thornton-Northglenn communities. The

TABLE 15. Plutonium, Uranium, Americium, and Tritium Activity Concentrations in Groundwater Monitoring Test Holes

Location Number	Depth (Meters)	Plutonium Concentration[a] ($\times 10^{-9}$ µCi/mℓ)			Uranium Concentration[b] ($\times 10^{-9}$ µCi/mℓ)			Americium Concentration[c] ($\times 10^{-9}$ µCi/mℓ)			Tritium Concentration ($\times 10^{-9}$ µCi/mℓ)		
		April	June	September	April	June	September	April	June	September	April	June	September
1-60	6	< 0.23	< 0.25	< 0.09	13.2	17.5	20.4	< 0.08	< 0.15	< 0.43	1466	518	1270
2-60	7	< 0.05	< 0.67	< 0.08	20.5	23.9	18.7	< 0.08	< 0.55	< 0.17	< 560	1738	1322
3-60	9	< 0.04	< 0.06	< 0.12	4.0	4.9	10.9	< 0.07	< 0.12	< 0.09	< 541	N/A[d]	962
4-60	9	< 0.04	< 0.08	< 0.04	< 0.9	12.0	23.6	< 0.07	< 0.11	< 0.15	< 522	4317	7438
5-60	9	< 0.05	< 0.10	< 0.06	3.0	< 3.4	3.6	< 0.08	< 0.22	< 0.06	< 533	1254	1293
6-60	9	< 0.05	< 0.11	< 0.05	4.5	< 4.9	3.3	< 0.02	< 0.14	< 0.08	< 535	1367	1553
1-66	45	< 0.04	< 0.06	< 0.03	< 0.9	< 3.8	< 0.5	< 0.07	< 0.12	< 0.13	< 457	< 361	< 446
2-66	43	< 0.04	< 0.07	< 0.02	< 0.9	< 2.4	< 0.31	< 0.06	< 0.15	< 0.10	2017	< 393	1203
3-66	47	< 0.05	< 0.07	< 0.04	< 0.9	< 2.8	3.0	< 0.08	< 0.28	< 0.12	1393	910	1165
1-68	1	< 0.04	Dry	Dry	< 0.9	Dry	Dry	< 0.07	Dry	Dry	1400	Dry	Dry
2-68	1	< 0.05	Dry	Dry	< 0.9	Dry	Dry	< 0.08	Dry	Dry	780	Dry	Dry
3-68	1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
4-68	1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
1-71	9	< 0.05	< 0.06	< 0.06	< 0.9	< 5.6	0.6	< 0.15	< 0.12	< 0.13	< 506	< 528	< 431
2-71	9	< 0.04	< 0.08	< 0.04	< 0.1	< 5.4	1.0	< 0.07	< 0.13	< 0.13	< 523	< 441	< 428
3-71	8	< 0.04	< 0.08	< 0.03	< 0.9	< 2.2	0.5	< 0.08	< 0.20	< 0.06	< 513	< 530	< 422
4-71	7	< 0.06	< 0.13	< 0.03	9.9	< 4.5	4.9	< 0.07	< 0.12	< 0.15	< 463	402	< 453
5-71	9	< 0.04	< 0.07	< 0.03	6.7	< 4.4	1.3	< 0.07	< 0.13	< 0.08	649	< 381	< 424
6-71	9	< 0.05	< 0.13	< 0.03	29.0	28.5	21.8	< 0.07	< 0.21	< 0.13	4228	2509	2728
1-74	7	< 0.04	< 0.06	< 0.03	< 2.2	< 5.1	3.5	< 0.15	< 0.12	< 0.11	< 512	< 519	< 477
2-74	3	< 0.04	Dry	Dry	< 0.9	Dry	Dry	< 0.18	Dry	Dry	< 511	Dry	Dry
3-74	7	< 0.04	< 0.07	< 0.06	< 0.9	< 4.5	3.2	< 0.06	< 0.14	< 0.10	871	< 354	< 764
4-74	2	Dry	Dry	Dry	Dry	Dry	Dry	N/A	Dry	Dry	N/A	Dry	Dry
5-74	5	< 0.07	< 0.08	Dry	< 0.9	< 2.8	Dry	0.22	< 0.15	Dry	1403	< 356	Dry
6-74	2	Dry	Dry	Dry	Dry	Dry	Dry	N/A	Dry	Dry	N/A	Dry	Dry
7-74	15	< 0.05	< 0.08	< 0.05	< 0.9	< 1.8	2.5	< 0.08	< 0.15	< 0.06	< 519	< 439	< 469
8-74	12	< 0.04	< 0.09	< 0.07	14.8	< 4.8	2.3	< 0.08	< 0.15	< 0.06	< 510	< 383	< 425
9-74	6	< 0.04	< 0.06	< 0.11	6.0	14.3	21.3	< 0.06	< 0.13	< 0.07	< 507	< 527	< 465
10-74	3	< 0.04	< 0.09	< 0.05	10.0	13.9	15.4	< 0.03	< 0.35	< 0.18	< 526	< 533	< 480
11-74	6	< 0.05	Dry	Dry	2.7	Dry	Dry	< 0.07	Dry	Dry	< 418	Dry	Dry
12-74	1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
13-74	6	< 0.04	< 0.08	< 0.04	5.4	< 3.8	5.2	< 0.07	< 0.14	< 0.13	< 537	< 348	444
14-74	1	< 0.04	Dry	Dry	< 0.9	Dry	Dry	< 0.08	Dry	Dry	< 499	Dry	Dry
15-74	6	< 0.04	< 0.07	< 0.03	14.8	9.2	20.3	< 0.07	< 0.11	< 0.14	< 459	< 533	< 443
16-74	1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
17-74	5	< 0.04	< 0.07	< 0.04	31.6	26.0	17.2	< 0.08	< 0.14	< 0.15	< 477	742	< 454
18-74	2	< 0.04	< 0.07	< 0.13	41.3	43.8	49.9	< 0.06	< 0.18	< 0.14	< 510	< 522	< 430
21-74	81	< 0.05	< 0.07	< 0.06	< 0.8	< 2.5	1.8	< 0.08	< 0.14	< 0.11	< 496	< 531	< 430
22-74	96	< 0.05	< 0.07	N/A	4.0	< 5.1	N/A	< 0.07	< 0.13	N/A	< 509	< 352	N/A
WS-1	4	< 0.05	< 0.08	< 0.05	< 0.9	< 4.3	0.5	< 0.07	< 0.15	< 0.07	< 527	< 347	< 428
WS-2	3	< 0.06	< 0.06	< 0.03	2.1	< 3.2	3.2	< 0.07	< 0.18	< 0.07	969	< 499	< 433
WS-3	4	< 0.05	< 0.08	< 0.07	< 0.9	< 4.8	1.1	< 0.07	< 0.12	< 0.07	578	< 457	< 417

a. Radiochemically determined as plutonium-239 and -240.
b. Radiochemically determined as uranium-233, -234, and -238.
c. Radiochemically determined as americium-241.
d. N/A – not analyzed.

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TABLE 16. Plutonium, Uranium, and Americium Activity Concentrations in Public Water Supplies

	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_w
		Plutonium Concentration ($\times 10^{-9}$ μCi/mℓ)[a]			
Reservoirs					
Boulder	1	< 0.008	< 0.008	< 0.008	< 0.01
Dillon	1	< 0.006	< 0.006	< 0.006	< 0.01
Great Western	12	< 0.007	< 0.04	< 0.02	< 0.01
Ralston	1	< 0.004	< 0.004	< 0.004	< 0.01
South Boulder Diversion Canal	1	< 0.007	< 0.007	< 0.007	< 0.01
Standley	12	< 0.008	< 0.04	< 0.01	< 0.01
Drinking Water					
Arvada	4	< 0.004	< 0.01	< 0.008	< 0.01
Boulder	12	< 0.007	< 0.02	< 0.01	< 0.01
Broomfield	12	< 0.001	< 0.02	< 0.01	< 0.01
Denver	4	< 0.008	< 0.02	< 0.01	< 0.01
Golden	4	< 0.005	< 0.01	< 0.008	< 0.01
Lafayette	4	< 0.004	< 0.01	< 0.008	< 0.01
Louisville	4	< 0.005	< 0.01	< 0.008	< 0.01
Thornton	4	< 0.004	< 0.09	< 0.03	< 0.01
Westminster	12	< 0.007	< 0.02	< 0.01	< 0.01
		Uranium Concentration ($\times 10^{-9}$ μCi/mℓ)[b]			
Reservoirs					
Boulder	1	1.4 ± 0.1	1.4 ± 0.1	1.4 ± 0.1	0.01
Dillon	1	< 0.9	< 0.9	< 0.9	< 0.01
Great Western	12	< 1	< 12	< 3	< 0.03
Ralston	1	11.4 ± 0.3	11.4 ± 0.3	11.4 ± 0.3	0.1
South Boulder Diversion Canal	1	< 0.47 ± 0.04	0.47 ± 0.04	0.47 ± 0.04	< 0.01
Standley	12	< 2	< 11	< 4	< 0.04
Drinking Water					
Arvada	4	< 1	6.6 ± 0.6	< 3	< 0.03
Boulder	12	< 0.2	< 9	< 3	< 0.03
Broomfield	12	0.4 ± 0.3	< 12	< 2	< 0.02
Denver	4	< 1	< 4	< 2	< 0.02
Golden	4	< 1	< 2	< 2	< 0.02
Lafayette	4	< 1	< 3	< 1	< 0.01
Louisville	4	< 1	< 2	< 1	< 0.01
Thornton	4	< 1	< 3	< 2	< 0.02
Westminster	12	< 1	< 13	< 4	< 0.04

a. Radiochemically determined as plutonium-239 and -240. The Radioactivity Concentration Guide (RCG_w) for soluble plutonium in water is 1667×10^{-9} μCi/mℓ.

b. Radiochemically determined as uranium-233, -234, and -238. The most restrictive RCG_w for these insoluble uranium isotopes is $10{,}000 \times 10^{-9}$ μCi/mℓ.

(continued on p. 27)

weekly samples were composited into a monthly sample, and analyses were performed for plutonium, uranium, and americium concentrations. The results are presented in Table 16. Analyses for tritium concentrations were performed on the weekly samples; the results are presented in Table 17. Concentrations of plutonium, uranium, americium, and tritium in water samples collected at Great Western Reservoir and Standley Lake were less than 0.05 percent of the applicable RCG_w.[2, 3]

Tap or finished water from Boulder, Broomfield, and Westminster was collected weekly, composited monthly, and analyzed specifically for plutonium, uranium, and americium. Tritium analyses were performed on weekly grab samples. Quarterly grab

TABLE 16. Concluded

	Number of Analyses	C_{min}	C_{max}	C_{avg}	Percent of RCG_W
		Americium Concentration ($\times 10^{-9}$ μCi/mℓ)[c]			
Reservoirs					
Boulder	1	< 0.02	< 0.02	< 0.02	< 0.01
Dillon	1	< 0.03	< 0.03	< 0.03	< 0.01
Great Western	12	< 0.01	< 0.1	< 0.03	< 0.01
Ralston	1	< 0.03	< 0.03	< 0.03	< 0.01
South Boulder Diversion Canal	1	< 0.1	< 0.1	< 0.1	< 0.01
Standley	12	< 0.01	< 0.06	< 0.03	< 0.01
Drinking Water					
Arvada	4	0.002	< 0.02	< 0.01	< 0.01
Boulder	12	< 0.01	< 0.05	< 0.02	< 0.01
Broomfield	12	< 0.01	< 0.05	< 0.02	< 0.01
Denver	4	< 0.01	< 0.03	< 0.02	< 0.01
Golden	4	< 0.01	< 0.03	< 0.02	< 0.01
Lafayette	4	< 0.01	< 0.02	< 0.02	< 0.01
Louisville	4	< 0.01	< 0.06	< 0.02	< 0.01
Thornton	4	< 0.01	< 0.03	< 0.02	< 0.01
Westminster	12	< 0.01	< 0.05	< 0.02	< 0.01

c. Radiochemically determined as americium-241. The RCG_W for soluble americium-241 is 1330×10^{-9} μCi/mℓ.

samples of tap water were collected from the surrounding communities of Arvada, Denver, Golden, Lafayette, Louisville, and Thornton. These samples were analyzed specifically for plutonium, uranium, americium, and tritium. These results are presented in Tables 16 and 17. All values were less than 0.05 percent of the applicable RCG_W.[2, 3]

Drinking water standards have been adopted by the EPA[7] and the State of Colorado for alpha-emitting radionuclides (excluding uranium and radon) and for tritium. These standards are 5.55×10^{-1} and 740 Bq/ℓ (15×10^{-9} and $20{,}000 \times 10^{-9}$ μCi/mℓ), respectively. During 1980, the sum of the concentrations of plutonium and americium (alpha-emitting radionuclides) in all community tap water samples was less than 1.48×10^{-3} Bq/ℓ (0.04×10^{-9} μCi/mℓ). This value is less than 0.26 percent of the alpha standard. The tritium concentrations in Great Western Reservoir, Standley Lake, and in all community tap water samples averaged less than 18.5 Bq/ℓ (500×10^{-9} μCi/mℓ). This value is typical of background tritium concentrations in Colorado and represents less than 2.5 percent of the EPA and State of Colorado Drinking Water Standard for tritium.[3, 14]

Annual grab samples were collected from three additional regional reservoirs (Ralston, Dillon, and Boulder) and one stream (South Boulder Diversion Canal) at distances ranging from 1.6 to 96 kilometers (1 to 60 miles) from the Plant. These samples were collected to determine background data in water for plutonium, uranium, americium, and tritium. The analytical results are presented in Tables 16 and 17. A comparison of the regional reservoir data indicates that the plutonium, uranium, americium, and tritium concentrations in downstream reservoirs and community tapwaters are all within the range of background concentrations.

Soil Sampling and Analysis

Soil samples collected during 1980 are part of a long-range monitoring program. The program is

TABLE 17. Tritium Activity Concentrations in Public Water Supplies

	Number of Analyses	Concentration ($\times 10^{-9}$ μCi/mℓ) C_{min}	C_{max}	C_{avg}	Percent of RCG_w[a]
Reservoirs					
Boulder	1	< 500	< 500	< 500	< 0.05
Dillon	1	< 500	< 500	< 500	< 0.05
Great Western[b]	53	< 300	1000 ± 300	< 500[c]	< 0.05
Ralston	1	< 500	< 500	< 500	< 0.05
South Boulder Diversion Canal	1	< 500	< 500	< 500	< 0.05
Standley	53	< 300	1000 ± 600	< 500[c]	< 0.05
Drinking Water					
Arvada	4	< 400	< 500	< 400	< 0.04
Boulder	53	< 300	1000 ± 300	< 500	< 0.05
Broomfield	53	< 300	900 ± 600	< 500	< 0.05
Denver	4	< 400	500 ± 500	< 500	< 0.05
Golden	4	< 400	< 500	< 400	< 0.04
Lafayette	4	< 400	< 500	< 400	< 0.04
Louisville	4	< 500	700 ± 400	< 500	< 0.05
Thornton	4	< 500	600 ± 400	< 500	< 0.05
Westminster	53	< 300	1000 ± 400	< 500	< 0.05

a. The Radioactivity Concentration Guide (RCG_w) for tritium in water released to uncontrolled areas is 1,000,000 × 10^{-9} μCi/mℓ.
b. The State of Colorado Primary Drinking Water Regulation limit for tritium is 20,000 pCi/ℓ (20,000 × 10^{-9} μCi/mℓ).
c. These tritium concentrations are less than 2.5 percent of the drinking water regulation.

designed to provide information on possible migration of plutonium in soil and to provide data for comparison with the EPA proposed guidance on transuranium elements in the environment.[4] The program was initiated in 1979 and will continue at least through 1983.

Samples were taken at four locations west of Indiana Street within the eastern boundaries of the Plant. The sites are shown on Figure 10 as numbers 13, 16, 21, and 28. Sites 13 and 21 were sampled in 1979; sites 16 and 28 were sampled in 1980. The EPA comparison study has been performed at sites 13, 21, and 28 and will be continued at three additional locations in the future. The migration study is underway at site 16.

Nine composite samples, each composed of nine subsamples, were collected at site 28 north of Woman Creek. Collection was done according to published procedures.[4, 15] Each set of nine subsamples was collected on a spacing of 20 meters (65.6 feet) and composited to yield one of the nine final samples. The geometry of each subsample was controlled by use of a 10 × 10 × 1 centimeter (4 × 4 × 0.4 inch) cutting tool. The soil contained within the tool cavity was removed and analyzed for plutonium.

The plutonium concentrations in soil samples at sites 13, 21, and 28 are shown in Table 18.

Data for 1979 are included with the 1980 data to correct an error made in calculating distribution values (mCi/km^2) for 1979. As shown in Table 18, the values for the three locations range from 2.8 × 10^1 to 1.48 × 10^2 Bq/kg (0.75 to 4.01 pCi/g). The relative standard deviations of about 20 percent indicate that the plutonium deposition is uniformly distributed at all three locations. The maximum surface distribution, 9.6 × 10^8 Bq/km^2 (26 mCi/km^2), is 13 percent of the EPA proposed guideline for plutonium in soil.[4]

FIGURE 10. Locations of Soil Sample Sites for 1980

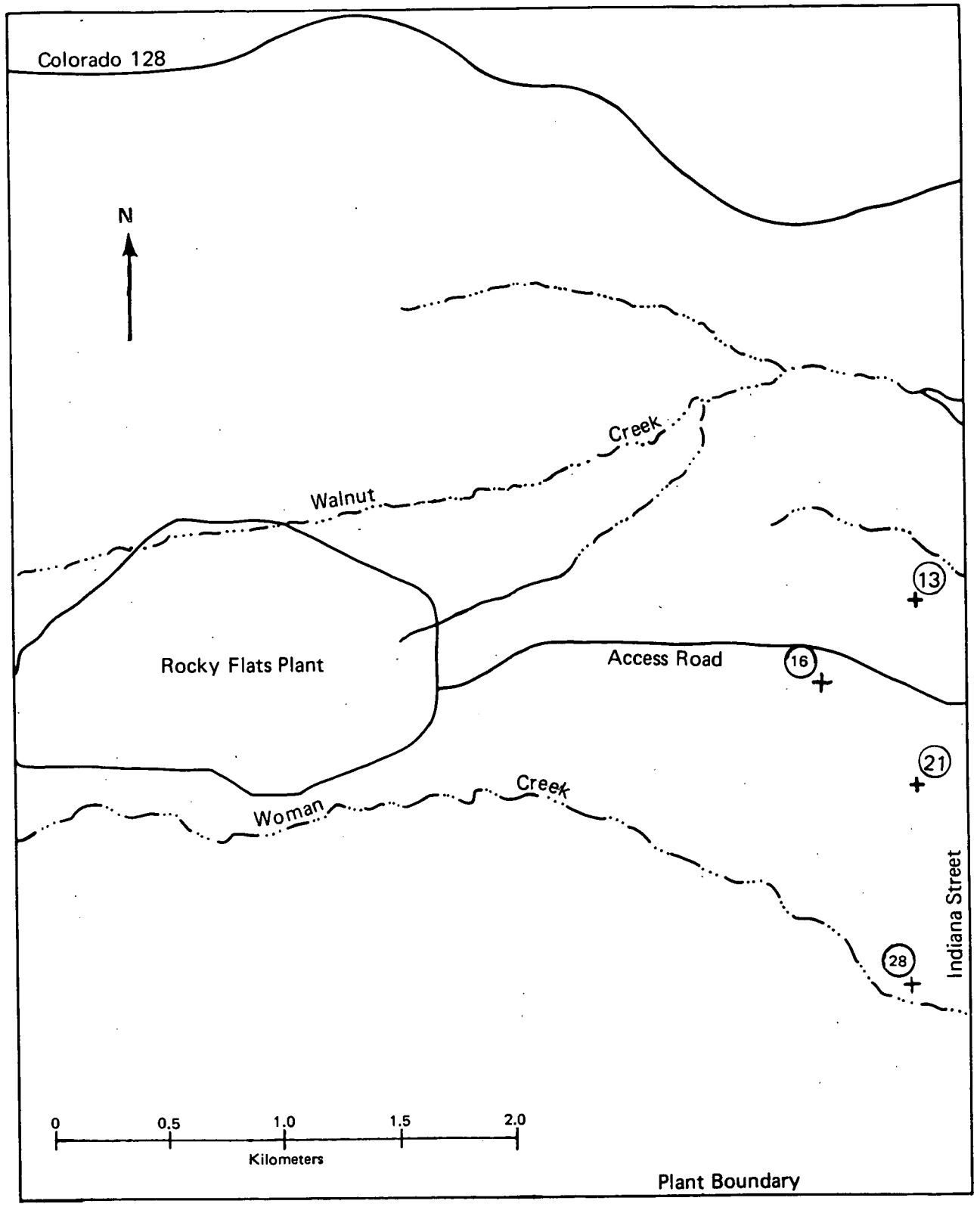

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TABLE 18. Plutonium Concentrations in Surface Soil Samples at the East Boundary of the Rocky Flats Plant (1979 and 1980)

Location	pCi/g[a]	mCi/km²[b]	Location	pCi/g[a]	mCi/km²[b]	Location	pCi/g[a]	mCi/km²[c]
13-1	2.84 ± 0.24	19	21-1	4.01 ± 0.36	22	28-1	1.03 ± 0.07	16
13-2	1.77 ± 0.10	13	21-2	2.13 ± 0.14	17	28-2	0.75 ± 0.05	10
13-3	2.34 ± 0.21	14	21-3	3.22 ± 0.44	19	28-3	1.09 ± 0.07	16
13-4	3.52 ± 0.19	26	21-4	2.08 ± 0.30	20	28-4	0.93 ± 0.07	13
13-5	3.01 ± 0.42	14	21-5	3.21 ± 0.31	21	28-5	1.22 ± 0.08	16
13-6	2.44 ± 0.19	13	21-6	2.32 ± 0.18	19	28-6	0.87 ± 0.07	14
13-7	2.35 ± 0.10	17	21-7	2.02 ± 0.21	21	28-7	0.88 ± 0.06	9
13-8	2.54 ± 0.15	15	21-8	2.46 ± 0.15	16	28-8	1.30 ± 0.08	13
13-9	3.27 ± 0.22	18	21-9	3.31 ± 0.22	22	28-9	1.49 ± 0.10	19
Mean	2.68 ± 0.07	17	Mean	2.75 ± 0.09	20	Mean	1.06 ± 0.02	14
Median	2.54	15	Median	2.46	20	Median	1.03	14
RSD[d]	20%	25%	RSD[d]	25%	11%	RSD[d]	22%	21%

a. Concentrations are for the fraction of soil measuring less than 2 millimeters in size.
b. 1979 data recalculated; original calculations used disintegrations per minute per gram (d/m/g) instead of picocuries per gram (pCi/g).
c. Samples collected to a depth of 1 centimeter.
d. Percent relative standard deviation.

The first series of samples for the migration study was taken at site 16. (See Figure 10.) Thirty samples, made up of 5 composites each, were taken at 15 locations. These locations were selected on a random basis from a grid of 64 squares [2 meters (6.6 feet) on each side of a square] separated by alleys one meter wide. The subsamples were taken from the four corners and the center of each square. The remaining squares will be sampled in subsequent years to determine surface and depth changes in plutonium concentrations.

The samples from each square consisted of surface and core samples. Surface material was taken by means of a 10 X 10 X 5 centimeter (4 X 4 X 2 inch) cutting tool, and soil from the interior of the tool was carefully removed for analysis. The core samples were taken from the same sites as the surface samples by means of an orchard auger measuring 8.3 centimeters (3.3 inches) in diameter. The depth of the cores was from 5 to 20 centimeters (2 to 8 inches). Surface samples and core samples were retained as individual samples but received identical preparation and analysis.

Plutonium concentrations in surface soil and soil core samples at site 16 are shown in Table 19. The range of values for surface samples at site 16 was between 2.28×10^2 and 4.59×10^2 Bq/kg (6.16 and 12.4 pCi/g) with a mean of 3.30×10^2 Bq/kg (8.93 pCi/g). Core samples contained plutonium in the range of 2.2×10^1 to 7.7×10^1 Bq/kg (0.60 to 2.08 pCi/g). These values are all within the range of concentration determined by the Environmental Measurements Laboratory in 1970.[8]

Vegetation Sampling and Analysis

Vegetation from the Rocky Flats Plant is periodically sampled and analyzed for plutonium-239 and -240, plutonium-238, and americium-241. This sampling is part of a long-term ecological monitoring program designed to aid in evaluating the environmental impact of the Plant. A comparison of these data with that from vegetation samples collected in succeeding years will allow an evaluation of whether radionuclide levels are following a long-term trend or are remaining stable.

During September 1979, all standing vegetation was clipped from 1.0-m² frames located randomly at two sites in each of two plots (Figure 11). The

TABLE 19. Plutonium Concentrations in Soil Samples From Within the Eastern Boundaries of the Rocky Flats Plant in 1980

Location[c]	Surface[a] (pCi/g)[d]	Core[b] (pCi/g)[d]
16-5	6.16 ± 0.37	0.72 ± 0.06
16-10	8.68 ± 0.46	0.70 ± 0.05
16-12	8.98 ± 0.45	0.98 ± 0.04
16-13	7.40 ± 0.45	1.03 ± 0.07
16-21	9.59 ± 0.55	1.42 ± 0.11
16-28	8.66 ± 0.46	0.84 ± 0.06
16-34	7.34 ± 0.39	0.60 ± 0.05
16-40	8.40 ± 0.29	1.00 ± 0.03
16-49	12.40 ± 0.70	1.46 ± 0.10
16-50	7.52 ± 0.21	1.46 ± 0.09
16-51	11.10 ± 0.72	1.60 ± 0.04
16-55	9.92 ± 0.25	1.61 ± 0.08
16-56	10.80 ± 0.70	1.73 ± 0.04
16-59	6.96 ± 0.15	1.15 ± 0.04
16-64	10.00 ± 0.23	2.08 ± 0.06
Mean	8.93 ± 0.13	1.22 ± 0.02
Median	8.68	1.15
RSD[e]	19%	35%

a. Sampled to a depth of 5 centimeters (2 inches).

b. Sampled from 5 to 20 centimeters (2 to 8 inches).

c. The first number of each location refers to site 16 as shown in Figure 10. The second number is the sample location on the grid at site 16.

d. Concentrations are for the less than 2-millimeter size fraction of soil.

e. Percent relative standard deviation.

vegetation was separated into three life form categories: forb, annual grass, and perennial grass. Perennial grass samples collected from Lafayette, Colorado, approximately 16 kilometers (10 miles) northeast of the Plant, were employed as controls. The two samples from each category were submitted to the Health, Safety and Environmental Laboratories for ashing and radionuclide analyses. The individual sample results are listed in Table 20. Statistical comparisons were not employed because of the frequency of "less than" values and because the reagent blank activity, in many cases, was indistinguishable from sample activity.

Hay is harvested annually from 300 acres of revegetated wheat fields in the southeast corner of the Plant site. Three randomly selected samples of the hay were analyzed for plutonium. Results of the analyses showed plutonium concentrations of 0.74, 0.37, and 0.37 Bq/kg (0.02, 0.01, and 0.01 pCi/g).

External Gamma Radiation Dose Monitoring

Thermoluminescent dosimeters (TLD's) are used to measure external penetrating gamma radiation exposure at 45 locations on and off the Plant site.

Individual measurements are made over an exposure period of three months. The TLD's are placed at 17 locations within the property enclosed by the security fence shown in Figure 2. Measurements are also made at 16 perimeter locations 3 to 6 kilometers (2 to 4 miles) from the Plant and in 12 communities located within 50 kilometers (30 miles) of the Plant. The TLD's are placed at a height of 1 meter (3 feet) above ground level.

Each TLD consists of a sealed glass bulb enclosing two extruded ribbons of CaF_2:Mn (TLD-400) that sandwich a central metal heater strip. The TLD's are encased in an energy-compensating shield to reduce over-response to photons with energies less than about 100 keV. The use of TLD's for assessing external penetrating radiation in the environment has been evaluated under field and laboratory conditions and has been found to be a sensitive and reliable tool for environmental measurement of gamma radiation exposure.[16]

The 1980 environmental measurements made using TLD's are summarized in Table 21. The average annual dose equivalents, as measured onsite, in the perimeter environs, and in communities, were 1.58, 1.41, and 1.60 mSv (158, 141, and 160 mrem), respectively. These values are indicative of background gamma radiation exposures in the area.[9]

ASSESSMENT OF POTENTIAL PLANT CONTRIBUTION TO PUBLIC RADIATION DOSE

Potential public radiation dose commitments, which could have resulted from Plant operations,

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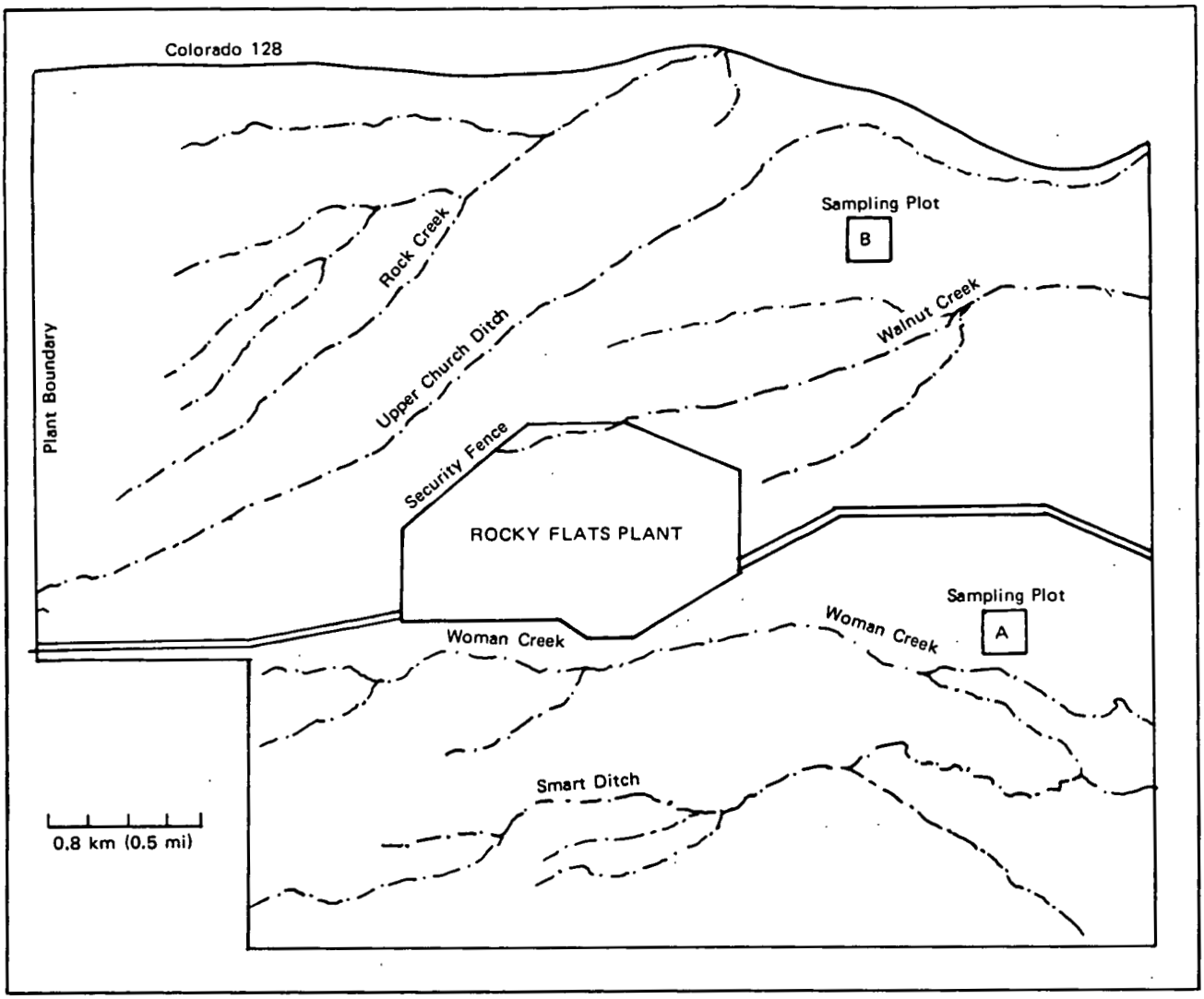

FIGURE 11. Location of Vegetation Sampling Plots

were calculated from average radionuclide concentrations measured at the DOE property boundaries and in surrounding communities. Inhalation, water ingestion, and ground plane irradiation were found to be the principal pathways of exposure. Swimming and consumption of foodstuffs and fish were found to be insignificant pathways. This latter finding is to be expected because of limited swimming and fishing in the area and because most locally consumed food is produced at considerable distances from the Plant.

Dose assessment for 1980 Plant operations was conducted for several locations: the DOE property (site) boundary, nearby communities, and sites to a distance of 80 kilometers (50 miles). Dose conversion factors used for the calculations were generated by computer codes that are described in detailed reports.[17, 18] These conversion factors are listed in Table 22. The inhalation rate of 2.66×10^{-4} m^3/s and the water ingestion rate of 1.65 liters (1.75 quarts) per day were derived from data for reference man,[19] and were included in the dose

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TABLE 20. Radioactivity Concentrations in Vegetation From Plots A and B

(Values are picocuries per gram of ash)

		^{239,240}Pu	^{238}Pu	^{241}Am
Plot A	Forb	0.56	0.03	0.15
		0.37	0.04	0.14
	Annual Grass	0.11	< 0.04	0.04
		0.06	0.04	0.05
	Perennial Grass	< 0.02	< 0.02	< 0.05
		0.02	< 0.02	< 0.03
Plot B	Forb	< 0.02	< 0.03	0.16
		0.05	< 0.02	0.16
	Annual Grass	0.04	< 0.03	< 0.03
		0.04	< 0.03	< 0.04
	Perennial Grass	< 0.02	< 0.04	0.05
		0.03	< 0.03	< 0.02
Control	Perennial Grass	0.04	< 0.03	< 0.04
		0.04	< 0.03	0.03
	Reagent Blank[a]	0.05	0.06	0.04

a. The reagent blank value was not subtracted from vegetation analyses.

TABLE 21. Environmental Thermoluminescent Dosimeter Measurements

Location Category	Number of Locations	Number of Measurements	Annual Measured Dose (mrem)
Onsite	17	131	158 ± 4
Perimeter	16	116	141 ± 6
Community	12	91	160 ± 8

TABLE 22. Dose Conversion Factors Used in Dose Assessment Calculations[a]

	Inhalation[b] $\left(\frac{\text{rem·cubic meter}}{\text{curie}}\right)$	Water Ingestion[c] $\left(\frac{\text{rem·liter}}{\text{curie}}\right)$			Ground Plane Irradiation $\left(\frac{\text{rem·square meter}}{\text{curie}}\right)$	
Organ	Pu-239, -240	Pu-239, -240	Am-241	^{3}H	Pu-239, -240	Am-241
Total Body	8.60×10^{10}	5.22×10^{6}	5.33×10^{7}	4.41×10^{4}	2.84×10^{3}	7.57×10^{3}
Liver	9.99×10^{12}	6.03×10^{8}	6.21×10^{9}	(d)	(d)	(d)
Bone	2.50×10^{13}	1.51×10^{9}	1.49×10^{10}	(d)	(d)	(d)
Lung[e]	6.31×10^{12}	(d)	(d)	(d)	(d)	(d)

a. These factors are taken from the Rocky Flats Plant Environmental Impact Statement.[1]

b. For 0.3-μm AMAD (Activity Median Aerodynamic Diameter), inhalation rate of 2.66×10^{-4} m^3/s for chronic exposure.[19]

c. For intake rate of 1.65 liters (1.75 quarts) per day.[19]

d. The values for the conversion factor are taken to be equal to that for the total body.

e. Assumed to be Class Y solubility, which is the least soluble of three solubility classes as defined by the ICRP (ICRP Publication 19, International Commission on Radiation Protection, May 1972).

conversion factors. Each of these dose conversion factors is for a 70-year dose commitment from one year of chronic exposure.

Dose Assessment Source Terms

Plutonium and americium in the Rocky Flats environs are the combined result of fallout deposition from atmospheric nuclear weapons testing and of past releases from the Plant. Uranium, a naturally occurring element, is indigenous to many parts of Colorado and is also used in Plant operations in various isotopic ratios. Tritium, a radionuclide formed by natural processes, also is associated with Plant operations and fallout.

The inhalation source terms for the 1980 dose assessment were based on plutonium-239 and -240 concentrations measured in ambient air samples. Because of the presence of plutonium from atmospheric weapons testing in previous years, these concentrations are an overestimate of the Rocky Flats contribution. The ingestion source terms were based on measured concentrations of plutonium, americium, uranium, and tritium in water. The ground plane source terms were based on measured values of plutonium in soil and an assumed ratio of americium to plutonium alpha activity (0.20) in the soil. This ratio is the maximum level of americium in-growth from Rocky Flats plutonium.[1]

The maximum site-boundary dose assessment assumes that an individual is continuously present at the Plant perimeter, which actually is uninhabited. The plutonium inhalation source term of less than 4×10^{-7} Bq/m^3 (1×10^{-17} Ci/m^3) was the maximum concentration of plutonium-239, and -240, as measured for a single perimeter location in the perimeter ambient air sampling network.

The water supply for the individual at the site boundary was assumed to be Walnut Creek, which flows offsite and provides the liquid effluent source term at the site boundary. During 1980, the plutonium concentration in Walnut Creek averaged 1×10^{-3} Bq/ℓ (3×10^{-14} Ci/ℓ). The average americium concentration was less than 1×10^{-3} Bq/ℓ (3×10^{-14} Ci/ℓ). These concentrations were used as the water ingestion source term for the maximum site boundary dose assessment. The average measured tritium concentration in Walnut Creek was 3×10^{1} Bq/ℓ (7×10^{-10} Ci/ℓ). Regional waters typically are measured at a concentration of 2×10^{1} Bq/ℓ (5×10^{-10} Ci/ℓ). The source term for tritium ingestion was the difference of these two concentrations [7 Bq/ℓ (2×10^{-10} Ci/ℓ)]. The average concentration of uranium in Walnut Creek was 2×10^{-1} Bq/ℓ (6×10^{-12} Ci/ℓ). The concentration of uranium in raw water, flowing onto the Plant, was 3×10^{-1} Bq/ℓ (9×10^{-12} Ci/ℓ), which exceeds the average for Walnut Creek. Rocky Flats contribution to uranium in the water was therefore omitted from the dose assessment.

The ground-plane irradiation source term is based on the maximum plutonium in soil deposition at the Plant perimeter, as reported by the Environmental Measurements Laboratory.[8] This source term is 1×10^{3} Bq/m^2 (3×10^{-8} Ci/m^2). The americium is assumed to be present at an alpha activity level of 20 percent that of the plutonium, which is the maximum quantity of americium that can be present in Rocky Flats plutonium from the decay of plutonium-241.[1] The americium source term is therefore 2×10^{2} Bq/m^2 (6×10^{-9} Ci/m^2).

The inhalation source term for the community dose assessment was based on plutonium concentrations measured at nine community air samplers. The 1980 average concentration of less than 4×10^{-7} Bq/m^3 (1×10^{-17} Ci/m^3) was the inhalation source term.

The ingestion source term for plutonium and americium in the communities was based on measured concentrations of tap water in nine communities. Rocky Flats effluent waters, however, are not tributary to water supply reservoirs for most of the regional communities. The data did not indicate measurable differences in concentrations for the different communities; therefore, averages of the 1980 concentrations in each of the communities were used for the source terms. These values for plutonium and americium were less than 4×10^{-4} and 7×10^{-4} Bq/ℓ (1×10^{-14} and 2×10^{-14} Ci/ℓ), respectively. As explained previously, the Rocky Flats contribution to uranium in the Plant's effluent watercourses was considered to be zero; therefore, the source

term for uranium in the communities that could have resulted from 1980 site operations was also zero.

Measured concentrations of tritium in the surrounding communities averaged 2×10^{1} Bq/ℓ (5×10^{-10} Ci/ℓ). The same average value was measured in the raw water supply to the Plant. The tritium concentration from Rocky Flats to the community water supplies was therefore determined to be zero.

The ground-plane irradiation source term is based on estimates of the Rocky Flats contribution to plutonium in soil in the area surrounding the Plant.[1] The americium is assumed to be 20 percent of the alpha activity of the plutonium, as discussed in the site-boundary source term. The source term values for plutonium and americium are 7 and 1 Bq/m^2 (2×10^{-10} and 4×10^{-11} Ci/m^2), respectively.

A summary of the source terms for the maximum site boundary and for community locations is tabulated in Table 23.

Maximum Site Boundary Dose

The maximum dose to an individual continuously present at the site boundary is based on the radionuclide concentrations shown in Table 23. From these concentrations and the dose conversion factors in Table 22, a 70-year dose commitment of less than 6×10^{-7} Sv (6×10^{-5} rem) is calculated for the total body. The corresponding bone dose is less than 8×10^{-6} Sv (8×10^{-4} rem). The DOE radiation protection standards for individuals in uncontrolled areas are 5×10^{-3} Sv (5×10^{-1} rem) annually for the total body and 1.5×10^{-2} Sv (1.5 rem) each year for mineral bone.[2] The maximum site boundary dose represents less than 0.01 percent of the standard for total body and less that 0.05 percent of the standard for mineral bone.

Maximum Community Dose

Based on the radionuclide concentrations in surrounding communities (Table 23), the calculated 70-year dose commitments were less than 2×10^{-8} Sv (2×10^{-6} rem) to the total body and less than 6×10^{-6} Sv (6×10^{-4} rem) to the bone. These values represent less than 0.001 percent and 0.1 percent, respectively, of the 1.7×10^{-3} Sv (1.7×10^{-1} rem) total body standard, for a suitable sample of the exposed population, and 5×10^{-3} Sv (5×10^{-1} rem) standard for mineral bone.[2]

The maximum site boundary and community dose commitments are summarized in Table 24. These

TABLE 23. Radioactivity Concentrations Used for 1980 Dose Calculations

	Air (Ci/m^3)	Water (Ci/ℓ)			Surface Deposition (Ci/m^2)	
Location	Pu-239, -240	Pu-239, -240	Am-241	^{3}H	Pu-239, -240	Am-241
Maximum Site Boundary	$< 1 \times 10^{-17}$	$< 3 \times 10^{-14}$	$< 3 \times 10^{-14}$	2×10^{-10}	3×10^{-8}	6×10^{-9}
Community	$< 1 \times 10^{-17}$	$< 1 \times 10^{-14}$	$< 2 \times 10^{-14}$	0	2×10^{-10}	4×10^{-11}

TABLE 24. 70-Year Dose Commitment From One Year of Chronic Intake/Exposure

Source	Total Body (rem)	Liver (rem)	Bone (rem)	Lungs (rem)
Maximum Site Boundary Location	$< 6 \times 10^{-5}$	$< 4 \times 10^{-4}$	$< 8 \times 10^{-4}$	$< 1 \times 10^{-4}$
Community	$< 2 \times 10^{-6}$	$< 2 \times 10^{-4}$	$< 6 \times 10^{-4}$	$< 6 \times 10^{-5}$

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TABLE 25. Natural Radiation Background Dose for the Denver Metropolitan Area[a]

Source	Total Body[b] (rem/yr)	Liver[b] (rem/yr)	Bone (rem/yr)	Lungs (rem/yr)
Cosmic Radiation	0.050	0.050	0.050	0.050
Cosmic Radionuclides	0.0007	0.0007	0.0008	0.0007
External Terrestrial	0.072	0.072	0.057	0.072
Inhaled Radionuclides	---	---	---	0.100
Radionuclides in the Body	0.027	0.027	0.060	0.024
Total for One Year	0.1497	0.1497	0.1678	0.2467

a. The values in this table are a summary of values derived from Reference 9.
b. The values for the total body and liver are considered to be the same as the values reported for the gonads in Reference 9.

values may be compared to an average dose reported for the Denver area of 1.5×10^{-3} and 1.68×10^{-3} Sv/yr (1.5×10^{-1} and 1.68×10^{-1} rem/yr) to the total body and bone, respectively, from natural radiation. (See Table 25.)

Eighty-Kilometer Dose Estimates

The total 70-year dose commitment for all individuals, to a distance of 80 kilometers (50 miles), is based on the calculated maximum community dose estimate and an estimate of the total population within the 80-kilometer radius. The entire population is therefore assumed to receive the dose commitment as described for the communities [2×10^{-8} Sv (2×10^{-6} rem) total body and 6×10^{-6} Sv (6×10^{-4} rem) mineral bone]. The 1980 demographic estimate of 2,000,000 within 80 kilometers of Rocky Flats is based on 1980 census data. On this basis, the 80-kilometer total body and mineral bone doses are estimated to be less than 4×10^{-2} and 1.2×10^{1} man-sieverts (4 and 1200 man-rem) respectively. The corresponding doses from natural radiation background are 3×10^{3} and 3.3×10^{3} man-sieverts (3×10^{5} and 3.3×10^{5} man-rem) respectively.[9]

APPENDIX A
APPLICABLE GUIDES AND STANDARDS

The Rocky Flats Plant Environmental Monitoring Program includes evaluating Plant compliance with all relevant guides, limits, and standards. Guide values for radionuclides in ambient air and waterborne effluents have been adopted by the DOE and the CDH.[2,3] The guides are based on recommendations published by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurement (NCRP). Limits for nonradioactive pollutants in effluent water have been defined by an Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) discharge permit.[6] In 1976, the EPA also established standards for radionuclides in drinking water.[7] These drinking water standards have been adopted, in turn, by the State of Colorado.[14]

The Radioactivity Concentration Guides (RCG's) published by DOE and CDH include permissible concentrations of specific radionuclides and mixtures of radionuclides in air (RCG_a) and water (RCG_w) for controlled and uncontrolled areas.[2,3] These guides are reduced by a factor of three when applied to a suitable sample of the exposed population. Numerical values of the guides for specific radionuclides are cited in some of the tables presented in this report. The guides additionally restrict the concentration of radionuclides in a mixture such that the sum of the ratios of each radionuclide concentration to the appropriate concentration guide shall not exceed a value of 1. The guides further state that a radionuclide may be considered as not being present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture to the concentration guide for that radionuclide does not exceed one-tenth and (b) the sum of such ratios for all radionuclides considered as not being present in the mixture does not exceed one-fourth.

During 1980, average specific radionuclide concentrations in air and water were all less than one-tenth of the appropriate concentration guides for specific radionuclides. The sum of the ratios of these average concentrations to their respective RCG's was less than one-fourth for all air and water sampling locations. The measured concentrations in the tables have, therefore, been compared to the concentration guides for specific radionuclides rather than to the guide for mixtures.

The RCG's for each radionuclide are specified for soluble and insoluble material. For purposes of comparing concentrations to RCG's, the more restrictive of the two (soluble or insoluble) RCG's is used. In this report, the RCG's for americium, plutonium, uranium, and tritium are referenced. The more restrictive RCG's for americium, plutonium, and tritium are for soluble material; however, the more restrictive RCG's for uranium isotopes are for insoluble materials. Throughout this report, where a radionuclide concentration is expressed as the cumulative measurement of more than one isotope, the stated RCG used for comparison represents the most restrictive RCG for that grouping of isotopes. Plutonium concentrations measured at Rocky Flats represent the alpha radioactivity from plutonium isotopes 239 and 240, which constitute over 97 percent of the alpha radioactivity in plutonium handled at the Plant.

Reported uranium concentrations are the cumulative alpha activity from uranium-233, -234, and -238. Enriched and depleted uranium are the principal types of uranium handled at Rocky Flats. Uranium-235 is the major isotope by weight (93 percent) in enriched uranium; however, uranium-234 accounts for approximately 97 percent of the alpha activity of enriched uranium. In depleted uranium, the combined alpha activity from uranium-234 and -238 accounts for approximately 99 percent of the toal alpha activity. The uranium RCG's used in this report for air and water are those for uranium-233 and -234, which are the most restrictive.

The applicable EPA standard for beryllium (a nonradioactive material) in airborne effluents from

TABLE 26. Applicable Standards for Radioactive and Nonradioactive Materials

Legend

μCi	= microcuries	g	= grams
m^3	= cubic meters	40 CFR 61	= Code of Federal Regulations National Emission Standards for Hazardous Air Pollutants (USEPA)
mℓ	= milliliters	DOE	= Department of Energy
mg/ℓ	= milligrams per liter	NPDES	= National Pollutant Discharge Elimination System
SU	= standard units	CDH	= Colorado Department of Health
NTU	= Nepholometer Turbidity Unit		

Parameter	Applicable Guides and Standards	Reference
Airborne Effluents		
Plutonium-239, -240	NA[a]	NA
Uranium-233, -234, -238	NA	NA
Tritium	NA	NA
Beryllium	< 10.0 g/day	40 CFR 61.32 (a)
Ambient Air		
Plutonium-239, -240	$< 20.0 \times 10^{-15}$ μCi/mℓ	DOE Order 5480.1, CDH
Waterborne Effluents (Radioactive)		
Plutonium-239, -240	$< 1{,}667 \times 10^{-9}$ μCi/mℓ	DOE Order 5480.1, CDH
Uranium-233, -234, -238	$< 10{,}000 \times 10^{-9}$ μCi/mℓ	DOE Order 5480.1, CDH
Americium-241	$< 1{,}330 \times 10^{-9}$ μCi/mℓ	DOE Order 5480.1, CDH
Tritium	$< 1{,}000 \times 10^{-6}$ μCi/mℓ	DOE Order 5480.1, CDH

Discharge Limitations

Effluent Water Samples (Nonradioactive)	Monthly Average	Daily Maximum	Reference
pH	6.0–9.0 SU		NPDES Permit
Total Nitrogen	20 mg/ℓ (30-day average)		NPDES Permit
Nitrate as N	10 mg/ℓ	20 mg/ℓ	NPDES Permit
Total Phosphorus	8 mg/ℓ	NA	NPDES Permit
Fluoride	NA	1.7 mg/ℓ	NPDES Permit
Biochemical Oxygen Demand, 5-Day	10 mg/ℓ	25 mg/ℓ	NPDES Permit
Dissolved Oxygen	> 4 mg/ℓ (minimum)	> 2 mg/ℓ (minimum)	NPDES Permit
Suspended Solids	15 mg/ℓ	25 mg/ℓ	NPDES Permit
Total Chromium	0.05 mg/ℓ	0.1 mg/ℓ	NPDES Permit
Residual Chlorine[b]	NA	0.1 mg/ℓ	NPDES Permit
Oil and Grease	NA	10 mg/ℓ	NPDES Permit
Fecal Coliform Count	400 organisms/100 mℓ (7 day)		NPDES Permit
Turbidity	30 NTU		CDH
Color	30 units		CDH

a. NA – Not Applicable.
b. Monitored at Pond B-4.

Plant buildings is 10 grams per stationary source in a 24-hour period.[11] For ambient air, the applicable DOE and CDH RCG's for soluble plutonium-239 and -240 in uncontrolled areas and for the general population are 2.2×10^{-3} Bq/m^3 (60×10^{-15} μCi/mℓ) and 7.4×10^{-4} Bq/m^3 (20×10^{-15} μCi/mℓ), respectively.[2, 3]

The DOE and CDH soluble plutonium-239 and -240 RCG in waterborne effluents for the general population is 62 Bq/ℓ ($1{,}667 \times 10^{-9}$ μCi/mℓ).[2, 3] The comparable RCG for americium-241 in water is 49 Bq/ℓ ($1{,}330 \times 10^{-9}$ μCi/mℓ).[2, 3]

The most restrictive RCG for uranium-233, -234, and -238 in water is 370 Bq/ℓ ($10{,}000 \times 10^{-9}$ μCi/mℓ), which is the RCG for both uranium-233 and uranium-234.[2, 3]

In 1976, the EPA promulgated regulations for radionuclides in drinking water.[7] These regulations were effective on June 24, 1977, along with primary drinking water regulations for microbiological, chemical, and physical contaminants. The intent of the Safe Drinking Water Act was to ensure that each state has primary responsibility for maintaining drinking water quality. To comply with these requirements, the Colorado State Board of Health modified existing State drinking water standards to include radionuclides.[14] Two of these community drinking water standards are of interest in this report. The State standard for gross-alpha particle activity (including radium-266 but excluding radon and uranium) in community water systems is a maximum of 5.6×10^{-1} Bq/ℓ (15 pCi/ℓ or 15×10^{-9} μCi/mℓ). Americium and plutonium, which are alpha-emitting radionuclides, are included in this limit. The limit for tritium in drinking water is 740 Bq/ℓ (20,000 pCi/ℓ or $20{,}000 \times 10^{-9}$ μCi/mℓ).

The Rocky Flats Plant NPDES permit, which the EPA issued in 1974 to DOE, established sanitary effluent concentration limitations at the Sewage Treatment Plant, limitations for nitrate and pH in the discharge from Holding Pond A-3 in the Walnut Creek drainage, and monitoring requirements for Pond C-1 in the Woman Creek drainage.

In addition to evaluating compliance with all relevant guides, limits, and standards, the Environmental Sciences Department assists operating groups in adhering to the DOE policy that "... operations shall be conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and economically practicable."[2]

Table 26 shows applicable standards for radioactive and nonradioactive materials.

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APPENDIX B
QUALITY CONTROL

A Quality Program Plan has been developed by the Environmental Analysis (EA) Group to provide controls for assurance that

- Current operating procedures exist for all phases of EA operations and that these procedures are implemented as written.
- Appropriate approvals are obtained prior to program initiation or change.
- The equipment used in sample collection and data analysis is appropriate to the assigned function and is operating as required.
- Accurate documentation exists for all programs, procedures, and actions.
- All variances from procedures or equipment use and performance are documented and explained with an impact assessment.
- Appropriate guidelines and standards for environmental monitoring are identified, and documentation of compliance is provided on a routine basis to Rocky Flats management, DOE, and State and Federal regulatory agencies.

The Quality Program Plan establishes control points and delineates responsibilities for specific categories of activities; provides an information base from which procedures can be developed, updated, and/or implemented; establishes a state of emergency preparedness in its contingency plans; and provides documental evidence of Rockwell's intent to comply with rules and regulations of Federal, State, and local regulatory agencies.

The plan includes quality assurance flow charts and quality matrices that illustrate activity networks and corresponding quality elements of each responsibility area. A complete listing of activities and responsibilities is also included in the Plan.

To ensure data reliability, the Health, Safety and Environmental Laboratories (HS&EL) Quality Control Program Plan outlines the quality control methods used in all phases of laboratory operations.

This quality control program includes the following elements:

- Development, evaluation, improvement, modification, and documentation of analytical procedures
- Scheduled instrument calibration, control charting, and preventive maintenance
- Participation in interlaboratory quality comparison programs
- Intralaboratory quality control programs

All sample batches scheduled for analysis by the HS&EL Central Receiving Laboratory contain an average of 10 percent control samples. The controls consist of both analytical blanks prepared in-house and standards prepared by the Rocky Flats Chemistry Standards Laboratory.

An analysis or group of analyses may be rejected and the sample or samples scheduled for reanalysis for one or more of the following reasons:

1. The chemical recovery is less than 10 percent or greater than 110 percent.
2. The analytical blanks in the analysis batch are out of acceptable range.
3. The standards in the analysis batch are not within acceptable limits of error.
4. The alpha energy spectrum is not acceptable because of the following:

a. extra and/or unidentified peaks

b. excess noise in background areas

c. poor resolution of peaks.

5. The chemist in charge of the laboratory believes there is reason to suspect the analysis.

Any unusual condition affecting the results, which is noted either during sample collection or analysis, is reported to Environmental Analysis.

Table 27 is a summary of HS&EL participation in the Rocky Flats Chemistry Standards Laboratories Bioassay and Environmental Measurements Program for 1980.

The HS&EL participate in two laboratory intercomparison programs:

1. The DOE Environmental Measurements Laboratory (EML) Crosscheck Program

2. The EPA Environmental Monitoring Systems Laboratory (EMSL) Crosscheck Program

Tables 28 and 29 summarize the HS&EL participation in both programs.

TABLE 27. Health, Safety and Environmental Laboratories Bioassay and Environmental Measurements Program Data for 1980

Isotopes Reported	Matrix	Method	Standard Range	Normal Sample Range	Annual Relative Error Percent[a]	Total Control Analyses
Pu-239, -240	Water	Alpha Spectral	0-20 d/m/ℓ[b]	0-2 d/m/ℓ	-10	60
Am-241	Water	Alpha Spectral	0-3 d/m/ℓ	0-1 d/m/ℓ	- 4	60
U-238, -234, -235	Water	Alpha Spectral	0-35 d/m/ℓ	0-20 d/m/ℓ	9	60
Pu-239, -240	Whatman Filters	Alpha Spectral	0-30 d/m/filter	0-10 d/m/filter	35	120
Am-241	Whatman Filters	Alpha Spectral	0-4 d/m/filter	0-2 d/m/filter	23	120
U-238, -234, -235	Whatman Filters	Alpha Spectral	0-30 d/m/filter	0-30 d/m/filter	- 3	120
Be[c]	Whatman Filters	Atomic Absorption[d]	0-1 μg/filter	0-2 μg/filter	116	120
Pu-239, -240	Microsorban Filters	Alpha Spectral	0-50 d/m/filter	0-20 d/m/filter	5	48
^{3}H	Water	Beta Liquid Scintillation	0-5 x 10^{4} pCi/ℓ	0-10^{4} pCi/ℓ	- 3	60
Sr-90[c]	Water	---	0-20 d/m/ℓ	0-15 d/m/ℓ	18	60

a. The ratio of the deviations of the 12-month differences to standard value in percent; i.e., observed value minus standard value divided by standard value times 100 equals the ratio as expressed in percent. The relative error for control measurements is often called the coefficient of variation where the dispersion of data (in this case, the average differences between measured and standard values) is divided by the average standard value submitted. This term is inclusive of all random and systematic error in the standards, analytical chemistry, and measurement process for a given nuclide, matrix, and procedure.

b. d/m/ℓ - disintegrations per minute per liter.

c. Analyzed by Rocky Flats Plant General Laboratories.

d. As of December 1980, submission level changed to 1-5 μg/filter.

TABLE 28. Health, Safety and Environmental Laboratories Participation in the Environmental Measurements Laboratory Crosscheck Program From October 1979 Through September 1980

Isotope Reported	Matrix	Submission Range	Method	Average RFP/EML*
Pu-239	Air Filter	0.60 → 1.20 pCi/filter	Alpha Spectral Analysis	1.57 ± 0.65
Am-241	Air Filter	0.60 → 1.20 pCi/filter	Alpha Spectral Analysis	1.14 ± 0.28
U-234	Air Filter	1.58 pCi/filter	Alpha Spectral Analysis	0.99 ± 0.27
U-238	Air Filter	1.58 pCi/filter	Alpha Spectral Analysis	0.92 ± 0.27
Pu-239	Soils	0.027 - 0.563 pCi/g	Alpha Spectral Analysis	3.58 ± 2.37
Pu-238	Soils	0.027 pCi/g	Alpha Spectral Analysis	4.81 ± 2.36
U-238 + U-234 + U-235	Soils	1.88 μg	Alpha Spectral Analysis	0.41 ± 0.05
Pu-239	Water	0.008 pCi/mℓ	Alpha Spectral Analysis	0.98 ± 0.14
Am-241	Water	0.0099 pCi/mℓ	Alpha Spectral Analysis	0.91 ± 0.31
U-234	Water	0.0125 pCi/mℓ	Alpha Spectral Analysis	0.80 ± 0.21
U-238	Water	0.0125 pCi/mℓ	Alpha Spectral Analysis	0.80 ± 0.21

$$* = \frac{\text{Rocky Flats Plant Reported Value}}{\text{EML Known Value}}$$

TABLE 29. Health, Safety and Environmental Laboratories Participation in the EPA Environmental Monitoring Systems Laboratory Crosscheck Program During 1980

Isotope Reported	Matrix	Method	Number of Analyses Reported	Relative Percent Error
Pu-239	Water	Alpha Spectral Analysis	1	-13.1
Alpha	Water	Total Alpha	1	33.3
^{3}H	Water	Beta Liquid Scintillation	3	- 3.9
Alpha	Air Filters	Total Alpha	1	15.6
Cs-137	Air Filters	Gamma Spectral Analysis	1	51.6

APPENDIX C
ANALYTICAL PROCEDURES

The Health, Safety and Environmental Laboratories (HS&EL) routinely perform the following analyses on environmental effluent samples:

1. Gross Alpha
2. Gross Beta
3. Gamma Spectral Analysis
4. Alpha Spectral Analysis (Pu-239, -238 Am-241, U-238, -233, -234, -235)
5. Beta Liquid Scintillation - Tritium
6. Iodometric Titration - Chlorine
7. Bacteria
8. Atomic Absorption - Beryllium

Procedures for these analyses were developed by the laboratory staff. The procedures for bacteria and chlorine analyses were developed following EPA guidelines. Soil procedures were developed following specifications set forward in "Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil," NRC Reg. Guide 4.5. All new procedures and changes to existing procedures must be thoroughly tested, documented, and be approved in writing by the Manager of HS&EL before being implemented. Environmental Analysis is notified of any major changes that could affect analytical results. All procedures are reviewed annually for consistency with state-of-the-art techniques, or at any time an analytical problem is suspected.

Copies of all procedures are kept on file in the office of the Manager of HS&EL.

The following is a general outline of the analytical procedures followed by the laboratories:

Samples received for gross alpha and gross beta screening are counted approximately 24 and 48 hours after collection. Samples exceeding the limits set by Environmental Analysis are recounted 72 hours after collection.

Water samples scheduled for gamma spectral analysis are poured into one-liter Marinelli® containers and are sealed before delivery to the gamma counting area. Routine water samples are counted for approximately eight hours. Samples requiring a lower detection limit are counted from 16 to 72 hours.

Soil samples scheduled for gamma spectral analysis are dried, sieved through a 10-mesh sieve, weighed, and the fine portion is ball-milled. The fine portion is then placed in a 500-milliliter Marinelli container and counted for at least 16 hours.

Filter samples scheduled for gamma analysis are placed in petri dishes and counted for approximately 16 hours.

All samples scheduled for alpha spectral analysis are analyzed in a similar manner regardless of matrix. Prior to dissolution, a known quantity of nonindigenous radioactive tracer is added to each sample. The tracer is used to determine the chemical recovery for the analysis. Tracers used include Pu-236, Pu-242, U-232, U-236, Am-243, and Cm-244. The type and activity level of the tracer used depends on the type and projected activity level of the sample to be analyzed.

After samples are dissolved, radioisotopes of concern are separated from each other and from the matrix material by various solvent extraction and ion exchange techniques. The purified radioisotopes are electrodeposited onto stainless steel discs. These discs are alpha counted for a minimum of 16 hours. If a lower minimum detection limit is required, samples may be counted from 72 to 168 hours depending upon the need. Samples that exhibit a chemical recovery of less than 10 percent or greater than 110 percent are automatically scheduled for reanalysis.

Tritium analyses are routinely performed on most environmental water samples as well as stack effluent samples. Five milliliters of the sample are combined with five milliliters of liquid scintillation cocktail mixture. Environmental samples are counted for 20 minutes and stack effluent samples are counted for 4 minutes. All samples are counted at least twice.

APPENDIX D
DETECTION LIMITS AND ERROR TERM PROPAGATION

The Rocky Flats Health, Safety and Environmental Laboratories (HS&EL) have adopted the following definition for detection limit, as given by Harley.[20]

> "The smallest amount of sample activity using a given measurement process (i.e. chemical procedure and detector) that will yield a net count for which there is confidence at a predetermined level that activity is present."

Making a reasonable estimate of the Minimum Detectable Activity (MDA) for a given radiochemical and counting procedure is complicated by the need to consider each of the following:

1. Detector background
2. Detector counting efficiency
3. Count time
4. Sample volume
5. Analytical blank
6. Type and amount of error allowable
7. Chemical yield or recovery for all steps within the process

During 1980, several significant changes took place in the manner in which the HS&EL calculated MDA. The changes were made to more realistically represent the sensitivity of the various analyses. These changes increased the calculated MDA reported by the laboratories; however, this does not indicate an increase in the activity level of the samples analyzed.

Following is a summarization of major changes effected in MDA calculations during 1980:

1. Prior to June 1980, chemical recovery was considered to be 100 percent for the purpose of MDA calculations. Acceptable calculated analytical recoveries range from 10 percent to 110 percent. Since June 1980, the actual chemical recovery is used in the MDA calculation. This results in an increase in the calculated MDA for all values of chemical recovery below 100 percent.

2. Two types of error are possible in estimating detection limits:

   Type I - concluding that activity is present when in fact, activity is not present

   Type II - concluding that activity is not present when in fact, activity is present.

   Prior to June 1980, only one type of error was considered in the MDA calculations. Calculations since June 1980 reflect the potential for both types of error to occur. The practical effect of this is to double the background, thus increasing the calculated MDA.

3. Beginning in January 1980, all data produced by the HS&EL have been reported as blank corrected. This includes the calculated MDA. A running average of the last five analytical blanks for the analysis and matrix under consideration is used for correcting MDA calculations. This causes an increase in the calculated MDA.

Table 30 shows the various formulae used for alpha data reduction during 1980.

Table 31 shows the typical MDA values for the various analyses performed by the HS&EL and by the General Laboratories. These values are based on an average sample volume, typical detector efficiency, detector background, count time, and chemical recovery. MDA values calculated for individual analyses may vary significantly depending on actual sample volume, chemical recovery, and analytical blank used.

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TABLE 30. Formulae for Activity and Uncertainty Calculations for the Alpha Spectral Analysis Systems

Non-Blank Corrected Sample Activity

$$A_{si} = \left[\frac{\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}}{\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}} \right] \frac{D_{sj}}{V \cdot 2.22}$$

Blank Corrected Sample Activity

$$B_{si} = A_{si} - A_{Ri}$$

Non-Blank Corrected Sample Uncertainty

$$a_{si} = \frac{1.96\, A_{si}}{V \cdot 2.22} \left[\frac{\frac{C_{si}}{T_s^2} + \frac{C_{Bi}}{T_B^2}}{\left(\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}\right)^2} + \frac{\frac{C_{sj}}{T_s^2} + \frac{C_{Bj}}{T_B^2}}{\left(\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}\right)^2} \right]^{1/2}$$

Blank Corrected Sample Uncertainty

$$b_{si} = (a_{si}^2 + a_{ri}^2)^{1/2}$$

Minimum Detectable Activity Calculation Before June 1980

$$L_{si} = \frac{3.29}{E_s \cdot V \cdot 2.22} \left[\frac{C_{Bi}}{T_s\, T_B} + \left(\frac{a_{ri} \cdot E_s}{1.96}\right)^2 \right]^{1/2}$$

Minimum Detectable Activity Calculation After June 1980

$$L_{si} = \frac{4.66}{Y \cdot E_s \cdot V \cdot 2.22} \left[\frac{C_{Bi}}{T_s\, T_B} + \left(\frac{a_{ri} \cdot E_s}{1.96}\right)^2 \right]^{1/2}$$

(continued)

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TABLE 30. (Concluded)

Legend

A_{Ri} = Non-blank corrected activity of laboratory reagent blank for isotope i expressed as picocurie per unit volume.

a_{ri} = Non-blank corrected uncertainty of laboratory reagent blank expressed as picocurie per unit volume.

A_{si} = Sample activity for isotope i expressed as picocurie per unit volume.

a_{si} = 95 percent confidence level uncertainty of a sample, expressed as picocurie per unit volume.

B_{si} = Blank corrected sample activity for isotope i expressed as picocurie per unit volume.

b_{si} = Blank corrected sample uncertainty expressed as picocurie per unit volume.

C_{Bi} = Detector background gross counts for isotope i.

C_{Bj} = Detector background gross counts for internal standard isotope j.

C_{si} = Sample gross counts for isotope i.

C_{sj} = Sample gross counts for internal standard isotope j.

D_{sj} = Activity (disintegrations per minute) of internal standard isotope j added to sample.

E_s = Absolute detection efficiency for sample detector.

L_{si} = Sample minimum detectable activity (MDA) for isotope i expressed as picocurie per unit volume.

T_B = Detector background count time expressed in minutes.

T_s = Sample count time expressed in minutes.

V = Sample unit volume or sample unit weight.

Y = Chemical recovery for sample.

TABLE 31. Detection Limits for Radioactive and Nonradioactive Materials

Legend

µCi	= microcuries	pCi	= picocuries
µg	= micrograms	mg/ℓ	= milligrams per liter
m^3	= cubic meters	SU	= standard units
mℓ	= milliliters	NTU	= Nepholometer turbidity units

Parameter	Approximate Detection Limit (per sample)	Approximate Sample Volume Analyzed[a]	Approximate Minimum Detectable Concentration
Airborne Effluent Samples			
Plutonium-239, -240	1.0×10^{-7} µCi	3,200 m^3[b]	0.03×10^{-15} µCi/mℓ
Uranium-233, -234, -238	2.0×10^{-7} µCi	3,200 m^3[b]	0.06×10^{-15} µCi/mℓ
Tritium	5.0×10^{-6} µCi	0.06 m^3	$83{,}000 \times 10^{-15}$ µCi/mℓ
Beryllium	1.0×10^{-3} µg	128 m^3[b]	8×10^{-6} µg/m^3
Ambient Air Samples			
Plutonium-239, -240	1.0×10^{-7} µCi	10,000 m^3[c]	0.01×10^{-16} µg/mℓ
Soil Samples (Radioactive)			
Plutonium-239, -240	1.0×10^{-1} pCi	10 g	0.01 pCi/g
Effluent Water Samples (Radioactive)			
Plutonium-239, -240	1.0×10^{-7} µCi	1,000 mℓ	0.1×10^{-9} µCi/mℓ[c]
Uranium-233, -234, -238	2.0×10^{-7} µCi	1,000 mℓ	0.2×10^{-9} µCi/mℓ
Americium-241	1.0×10^{-7} µCi	1,000 mℓ	0.1×10^{-9} µCi/mℓ[c]
Tritium	2.5×10^{-6} µCi	5 mℓ	0.5×10^{-6} µCi/mℓ
Effluent Water Samples (Nonradioactive)			
pH		Not Applicable	0-14
Total Nitrogen		10 mℓ	0.2 mg/ℓ
Nitrate as N		10 mℓ	0.3 mg/ℓ
Total Phosphorus		50 mℓ	0.2 mg/ℓ
Fluoride		20 mℓ	0.2 mg/ℓ
Biochemical Oxygen Demand, 5-Day		10 mℓ	1.0 mg/ℓ
Dissolved Oxygen		300 mℓ	1.0 mg/ℓ
Suspended Solids		100 mℓ	2.0 mg/ℓ
Total Chromium		5 mℓ	0.05 mg/ℓ
Residual Chlorine		10 mℓ	<0.1 mg/ℓ
Oil and Grease		500 mℓ	0.1 mg/ℓ
Fecal Coliform Count		10-100 mℓ	1 organism/100 mℓ
Turbidity			30 NTU
Color			30 units

a. Volume analyzed is usually an aliquoted fraction of the total sample volume collected.
b. Monthly composite.
c. Two-week composite.

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APPENDIX E
REPORTING OF MINIMUM DETECTABLE CONCENTRATION AND ERROR TERMS

Throughout the section entitled "Monitoring Data: Collection, Analyses, and Evaluation" in this report, all values that were measured at or below the calculated minimum detectable concentration (MDC) were assigned the MDC value for purposes of reporting and/or averaging. These values were reported in the form $<$a where "a" is the calculated MDC value. Average values in the report are preceded by the less-than sign ($<$) when one or more of the individual data points is at or below the MDC.

Error terms in the form of a ± b are included with selected data that were measured above the MDC. Error terms are not available for values that are assigned the MDC. For a single sample, "a" is the reagent-blank corrected value; for multiple samples it represents the average value (arithmetic mean). The error term "b" accounts for the propagated statistical counting uncertainty for the sample and the associated reagent blanks. These error terms represent a minimum estimate of error for the data. Other analytical and sampling errors are being investigated for future incorporation into an all-inclusive error term for each value.

REFERENCES

1. *Environmental Impact Statement, Rocky Flats Plant Site,* DOE/EIS-0064 U.S. Department of Energy, Washington, D. C., April 1980.

2. "Standards for Radiation Protection," DOE Order 5480.1, Chapter XI, Department of Energy, Washington, D. C., to be issued.

3. *Rules and Regulations Pertaining to Radiation Control,* Part IV, Colorado Department of Health, 1978.

4. *Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment,* EPA 520/4-77-016, U.S. Environmental Protection Agency, Washington, D. C., September 1977.

5. "National Primary and Secondary Ambient Air Quality Standards," 40 CFR Part 50, Subchapter C - Air Programs, 44 FR-8220, February 8, 1979.

6. NPDES Permit CO-0001333, National Pollutant Discharge Elimination System, U.S. Environmental Protection Agency, Washington, D. C., September 6, 1974.

7. "Drinking Water Regulations, Radionuclides," as published in the *Federal Register,* Vol. 41, No. 133, pp. 28402-09, July 9, 1976.

8. *Plutonium in the Soil Around the Rocky Flats Plant,* HASL-235, Health and Safety Laboratory, U.S. Atomic Energy Commission, August 1, 1970.

9. *Natural Background Radiation in the United States,* NCRP Report No. 45, National Council on Radiation Protection and Measurements, Washington, D. C., November 15, 1975.

10. D. L. Bokowski, "Rapid Determination of Beryllium by a Direct-Reading Atomic Absorption Spectrometer," in *American Industrial Hygiene Association,* 29:471-481, (1968).

11. "National Emission Standards for Hazardous Air Pollutants," 40 CFR Part 61, Subpart C, U.S. Environmental Protection Agency, Washington, D. C., March 3, 1978.

12. J. B. Wedding, *Determination of Sampling Effectiveness of Rocky Flats Hi-Volume Sampler and Filtration Efficiency of Microsorban-98 Fiber Filter,* Colorado State University, Fort Collins, Colorado, 1978.

13. *Report To The Public,* Air Pollution Control Commission, Colorado Department of Health, page 35, (1980).

14. *Primary Drinking Water Regulations Handbook,* State of Colorado, Water Quality Control Division, Colorado Department of Health, effective December 15, 1977.

15. "Environmental Analysis and Control Soil Sampling Procedure," Procedure EAC-S-4, Rockwell International, Rocky Flats Plant, Golden, Colorado.

16. T. F. Gesell, G. D. Burke, and K. Becker, "An International Intercomparison of Environmental Dosimeters," in *Health Physics* 30: 125-133, (1976).

17. J. R. Houston, D. L. Strenge, and E. C. Watson, *DACRIN - A Computer Program for Calculating Organ Dose From Acute or Chronic Radionuclide Inhalation,* BNWL-B-389, Battelle Pacific Northwest Laboratories, December 1974, (Reissued April 1976).

18. G. R. Hoener and J. K. Soldat, *Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Uptake,* NUREG-0172, Battelle Pacific Northwest Laboratories for U.S. Nuclear Regulatory Commission, November 1977.

19. *Report of the Task Group on Reference Man,* ICRP Publication 23, International Commission on Radiological Protection, 1975.

20. J. H. Harley, Ed., *Procedures Manual and Supplements 1-4,* Health and Safety Laboratory, U.S. Atomic Energy Commission, 1972.

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